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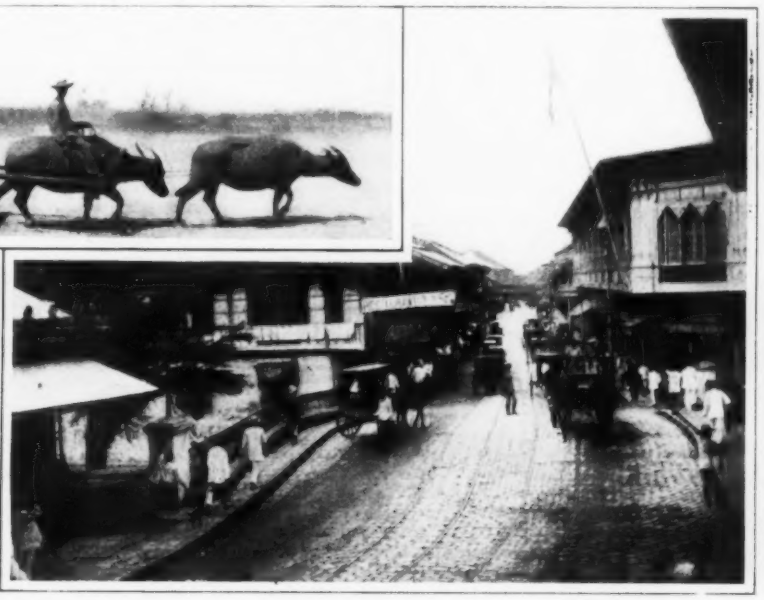
A FLOODED MANILA STREET.

OLD METHOD OF TRANSPORTATION.



THE OLD LINE WHICH THE NEW DISPLACED.

THE OLD STREET RAILWAY WHICH HAS NOW DISAPPEARED.

BONDING AND JOINTING RAIL IN CALLE REAL.

UPON THE ISLAND IN THE FOREGROUND THE POWER HOUSE WAS BUILT.

THE FIRST ELECTRIC RAILWAY OF MANILA.

THE FIRST PHILIPPINE ELECTRIC RAILWAY.

On Monday, April 10, the first electric railroad built in the Philippine Archipelago was formally opened. The Manila Electric Railroad and Lighting Corporation is the name of this newest American industrial enterprise in a foreign country. As the name would indicate, the company controls the lighting privileges as well, having purchased the old Spanish lighting company known as the "Electricista," the plant of which was antiquated and insufficient. Approximately thirty miles of 70-pound A. S. C. E. section tee rail has been laid, and ten miles of 94-pound girder rail. Most of the tee rail was supplied from Belgium, but manufacturers in the United States have made the last shipments. The girder rail is laid on a concrete base, with spacing ties every six feet. The tee rail is laid on wooden ties, 2-inch centers, standard, angle-bar joints, Harvey grip track bolts, and screw lag spikes, instead of standard railroad spikes. The screw lag spike was employed because of the toughness of the wood, for the tie had to be bored before the spike could be screwed in by the use of the socket wrench. Sole plates were used at all joints.

Climatic conditions compelled the use of teak ties, or of California, Australian, or Philippine native woods, treated with carbolineum or jodelite, this being done to afford protection against the ravages of the "white ant." So corrosive is the damp climate that rails and metal work are coated with asphaltum paint.

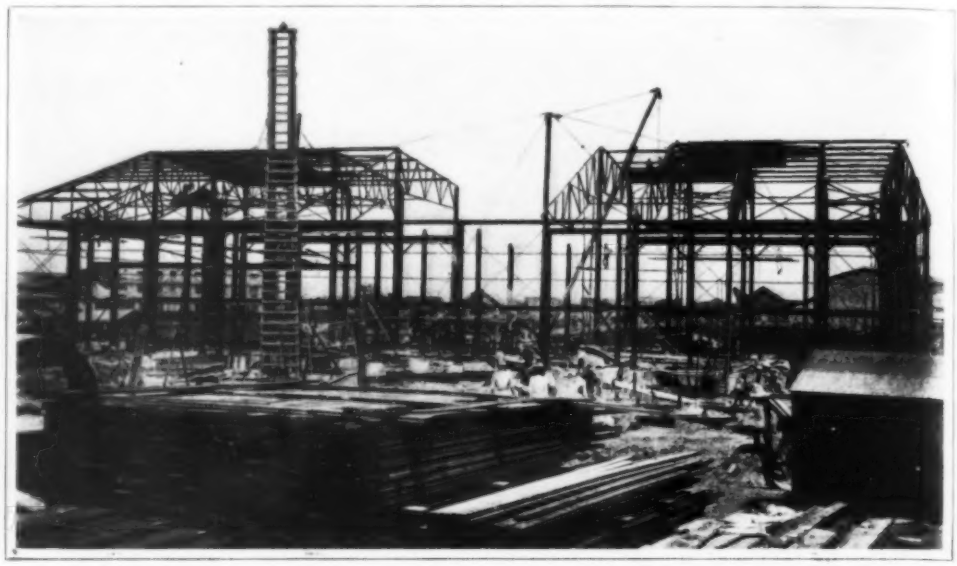
A large number of steel tubular poles were used in span and ornamental center bracket construction along the principal thoroughfares. However, after a thorough investigation, it was found that native wood poles would outlast the steel ones; and they have since been employed exclusively, although a 30-foot pole cost approximately $15, delivered on the work. No. 2-0 B. & S. copper trolley wire was used, in connection with an equivalent of twenty-five miles of 4-0 feeder.

The rolling stock at present consists of 100 cars of the standard, single and double truck, cross-bench, open-type cars. Because of white ants, woods ordinarily used in construction of cars for American roads would not answer at all. Consequently, teak was employed exclusively in woodwork. The streets are too narrow, within the city, to permit the use of double-truck cars; therefore they will be employed only on the suburban lines.

The equipment also includes three 500-kilowatt rotaries, 370-600 volts; one 125-kilowatt booster, direct connected with one of the above rotaries; one 300-kilowatt rotary, 370-600 volts; four 250-kilowatt oil-cooled transformers, 3,400-360 volts, 60 cycle, provided with taps; two 500-kilowatt transformers; one 50-kilowatt exciter (motor driven); two 37½-kilowatt exciters (steam driven); one switchboard complete. This board extends along one side of the building, is 105 feet in length, contains forty-four panels, and is completely equipped with all instruments necessary for measuring and recording all things in connection with the output, both alternating and direct current. It is so arranged that in case of accident on one circuit the panel controlling that circuit can be cut out and new panel substituted while repairs are being made.

Condensers.—Opposite each turbine is located, on the main floor, an Alberger counter condenser. Underneath, in the basement, is located the various auxiliary apparatus, used in connection with condensing, etc. Condensing water for the turbines is received through a concrete intake (running to one side of the island), is raised by centrifugal pump and forced through the condensers by gravity into another canal, which carries it away to the other side of the island.

In the boiler room the apparatus is as follows: Eight 400-horse-power Babcock & Wilcox boilers, equipped with superheaters; two Blake duplex plunger pumps; two Goubert feed-water heaters.



THE POWER HOUSE IN COURSE OF CONSTRUCTION.

The coal at present used is Australian, having a guaranteed B. T. U. of 13,000, and is unloaded from barges direct alongside the plant.

The use to which the current will be put was the factor that determined the somewhat unusual system of generation. It was decided to generate at 370 volts, alternating current, which would give a pressure of 600 volts direct current on the direct-current side of the rotaries. For high-tension lighting and distribution, the current is stepped up by aid of transformers.

The current will be used for supplying about 500 arc lights, 30,000 incandescent lights, and the power necessary for operating 100 cars over some forty miles of street railway. The current for the railway service will be carried on eight circuits, and that for the arc lighting will go over six high-tension circuits. A great deal of fan, motor, and other power business will be developed by the increased facilities for furnishing power.

The car barns are also of steel-concrete construction, and are complete in all particulars. They are large and roomy and built in the form of a hollow square, the outside being occupied by offices.

The shops are unusually well equipped, having been planned with the idea in view that, as soon as possible, all necessary repairs will be made therein, and eventually cars will be built in these shops, of native woods. The company has its own printing plant, which is also located in the shop, this being used for printing tickets, circulars, time-tables, etc., an institution made necessary by the distance from the base of supplies.

The operation of the system will compare favorably with that of any plant in the United States. The manager of the railway properties is Mr. R. T. Laffin, who has made a reputation in similar work at Boston. Portable screens will be used for dividing first from second class passengers, and the Canadian system of fare boxes is employed. The opening of the road was marked by public festivals and demonstrations, the city being gayly decorated for the occasion. The road was built by the J. G. White Company, of New York and London.

THE LUNCHMEN WHO SUPPLIED THE LABORERS WITH MEALS. THESE MEN WERE STATIONED NEAR THE LINE, SO THAT THE LABORERS COULD NOT GAMBLE AWAY THEIR MONEY IN THE CITY INSTEAD OF BUYING FOOD.

THE FIRST ELECTRIC RAILWAY OF MANILA.

"A PERTINACIOUS CURRENT."

At the Royal Institution Sir Oliver Lodge discoursed on what had quaintly been announced as a "pertinacious current." This mysterious title must have raised in electrical minds serious misgivings as to the real nature of the subject of the lecture; for, considering the personality of the lecturer, the current might equally well have been psychical, social, or merely physical. But doubts were dispelled on arrival in the theater by the sight of the table groaning under a great load of inductoriums, condensers, and vacuum tubes. At the very beginning of his discourse, Sir Oliver was good enough to satisfy all curiosity by an explanation. A pertinacious current is a continuous unidirectional discharge of electricity, obtained without cells, and under an E. M. F. so high that ordinary big resistances are easily over-ridden. The necessity of producing such currents by practical methods—that is, by a magnetic method, in contradistinction to the big battery method—had been thrust upon the lecturer by his experiments in fog-dispelling, where, of course, a high-potential unidirectional discharge is essential. A magnetic method has been found and, as many of our readers will remember, was described by Sir Oliver Lodge at a meeting of the Physical Society in November, 1903.

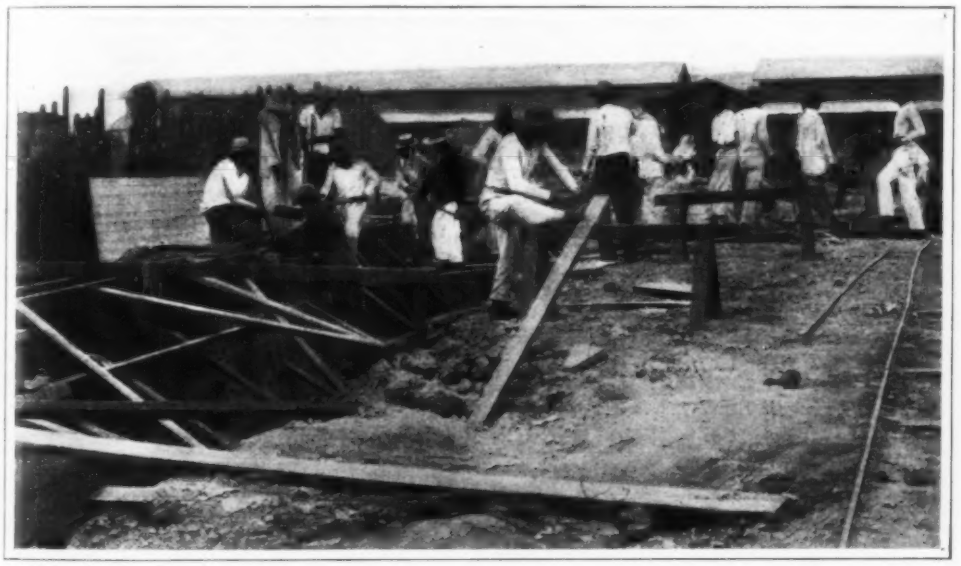
The method consists in using the mercury rectifier to trap in a reservoir the surges from an induction coil. The rectifier operates like a valve controlling the inlet of a cistern into which water is intermittently pumped. In this analogy the water stands for electricity, the pump for the induction coil, and the cistern for the Leyden jar of the electrical case. It was in the explanation of the internal action of the rectifier the interest of the evening mainly centered. Sir Oliver proposes the following excellent theory of the vacuum tube rectifier: He believes the current is carried through a rarefied gas chiefly by the positive particles, the electricity conveyed by the negative particles or corpuscles being comparatively small in amount. Anything which hinders the passage of the positive ions increases the effective electrical resistance of the tube. Now, the cathode rays, constituted as they are of corpuscles moving with immense velocities in the direction opposed to the much slower motion of the positive ions, may by the bombardment of the oncoming ions considerably hinder their direct advance. Indeed, as the vacuum of the tube is increased the plus carriers have increasingly greater difficulty in traveling from the anode to the cathode, and usually manage it only by creeping unobtrusively along indirect paths to those parts of the cathode from which the bombardment is least vigorous. In fact, it is found that the long-continued bombardment of the plus ions, which are probably merely atoms of the rarefied gas, can drive them right out of the tube and so produce the well-known effect of increasing the vacuum. Portions of gas may even be added and driven out in succession in this manner, and when there are no positive carriers left conduction becomes very difficult. To insure good conductivity, therefore, the positive carriers must be protected from the negative bombardment and must be given plenty of chance to reach the cathode.

This theory at once helps to an understanding, as Sir Oliver Lodge showed, not only of the main function of a mercury rectifier, but, besides, of the action of that small but very necessary adjunct to the mercury vapor tube—namely, the conducting coating outside the glass round the edge of the liquid mercury which acts as cathode at the bottom of the tube. This conducting Leyden-jar-like coating must be connected to the posi-

tive electrode by a wire outside the tube, or the tube is not a rectifier. The explanation of this phenomenon lies in the fact that the conducting coating when so connected establishes through the glass a strong electric field which diverts the cathode stream from the center of the vertical tube, thus leaving an open pathway for the positive carriers from the anode above. It is easy now to see why the tube is a rectifier, for if the outside terminals be imagined reversed, so that the mercury is anode and the upper iron electrode is cathode, a stream of undiverted cathode rays pours down the tube, stops the upward travel of the positive carriers, and renders conduction extremely difficult. Such a tube of average size will carry about 5 amperes from 100-volt mains when the plus ions move downward, but practically nothing when they must move upward.

Further, the theory proposed suggests new and efficient forms of rectifier. One such was described and exhibited by the lecturer. In it advantage is taken of the rectilinear propagation of the cathode rays, when they are free from the deflecting influences of a strong electric or a magnetic field. Here the cathode is a wire stretching vertically the length of the tube. The anode is a smaller electrode, surrounded by a horizontal narrow glass cone or cylinder. In this cone the positive carriers may reside in large numbers, well protected from the cathode ray bombardment, and, as fast as may be, escape from the open end of the cone with a fair chance of reaching the extended cathode. With such a tube Sir Oliver showed an interesting and instructive experiment. Reversing the terminals, the electrode in the cone becomes the cathode, and the negative corpuscles, by their bombardment, quickly eject the positive carriers from the region. On restoring to the terminals their proper signs an appreciable interval elapses before the tube lights up again in active conduction, showing at once the reality of the emptying process which had been applied to the region round the anode, and, besides, the comparatively slow rate of diffusion of the plus carriers back to their former home.

A number of effective experiments illustrated, during the hour, various applications—ranging from fog-dispelling and Röntgen-tube driving to the burning of a long wet string—of the pertinacious current afforded by Leyden jars kept supplied through a series of rectifiers with electricity from a large induction coil.—The Electrician.



THE LABORERS INSISTED ON USING THEIR NATIVE SAWS IN CUTTING UP TIMBER. THIS PICTURE SHOWS THEM AT WORK ON THE POWER HOUSE.

THE FIRST ELECTRIC RAILWAY OF MANILA.

THE SHILOAH TUNNEL: A HEBREW PARALLEL TO THE SIMPLON.

THE successful achievement of the piercing of the Simplon has recalled a parallel feat of engineering skill, although on a comparatively very insignificant scale, yet carried out more than twenty-five centuries ago. Dr. Bertholet, of Basle University, has drawn attention to this remarkable work, which seems to be the first recorded instance of tunneling in the rock.

Of King Hezekiah, who is supposed to have reigned in Jerusalem from 727 to 699 before the Christian era, we are told—II. Kings xx. 20—that he "made a pool, and a conduit, and brought water into the city," a statement confirmed by Jesus Sirach—xlviii. 17—who wrote:—"Hezekiah fortified his city by leading water into it, and he bored through the rocks with bronze and dammed the water into a pool." This boring through the rocks with bronze, in the opinion of modern scholars, refers to the Shiloah Tunnel through which the water of Mary's Spring, lying to the east of Jerusalem, was brought to the city into the pool of Siloam, mentioned in the fourth Gospel. Hezekiah's purpose seems to have been twofold—to supply Jerusalem with good water in case of a siege, and, at the same time, to cut off the water supply of the enemy. The latter reason is clear from a passage in Chronicles—xxxii. 4—where it is related how the people gathered together, and "stopped all the fountains and the brook that ran through the midst of the land," to forestall the Kings of Assyria, should they come to beleaguer the city. In the same chapter—xxxii. 30—it is said more explicitly that Hezekiah "stopped the watercourse of Gihon, and brought it straight down to the west side of the city of David." The surface canal, re-discovered in 1890, was constructed in the reign of Hezekiah's predecessor, and is probably referred to by Isaiah as the "waters of Shiloah that go softly." It was thus replaced by a much more efficient device, namely, an underground conduit.

So far, then, the at present existing Shiloah Tunnel had been identified with the work of the old Jewish king, but it was reserved for a mere chance to reveal the technical details of this ancient example of rock-piercing. In the year 1880 some boys, while bathing in the Shiloah tunnel, noticed an inscription, which, on examination, proved to be in old Hebrew characters, only slightly less primitive in form than those of the Moabite stone, while further investigations showed that the writing must be regarded as contemporary with the construction of the tunnel itself. In spite of a few lacunæ, the inscription has been read, and runs to the following effect:

"(Completed is) the piercing. And this was the manner of the piercing. When yet the pick of the one . . . against the other, and when there were still three ells (to pierce), then (one could hear) the voice of the one, who called to the other; for there was (a cleft) in the rock on the south side . . . and on the day of the final piercing the rock hewers struck against each other, pick against pick. Then flowed the waters from the outlet into the pool 1,200 ells distant. And 100 ells was the height of the rock above the heads of the hewers."

This description leaves no doubt as to the boring of the tunnel having been commenced from both ends simultaneously. A curious confirmation of the fact is, however, afforded by the circumstance that the marks of the tools run in opposite directions in the northern and southern halves.

The work was not carried out without hitches. It has been discovered that the direction had several times to be corrected, galleries already begun having been again abandoned. It would almost seem from the expression in the inscription that the successful meeting of the working parties was due to their hearing each other's voices. The compass, although said to have been known at a very early date in the Far East, could hardly have been at the disposal of Hezekiah's engineers. The result, however, was that the channel was a long way out of the straight line. The present length of the tunnel is 580 yards, the equivalent to which is, in round numbers, the 1,200 ells of the inscription, while the geometrical distance between the point of departure and the point of completion of the tunnel is only 363 yards. The meeting point of the tunnel borers is not far from the middle, being 269 yards from Mary's Spring, and 311 yards from the Shiloah Pool. The breadth of the tunnel varies from 3 feet to 2 feet, the height falls from nearly 10 feet at the southern opening, where presumably the constructors availed themselves of a natural fault in the rock, to a foot and a half, rising again to 6 feet at the northern outlet. In strong contrast with the failure of the constructors to keep in a straight line is the accuracy observed by them in maintaining the same horizontal level throughout the work. The whole difference in level amounts to no more than a foot. This circumstance has even led to the surmise that the old Israelites must have possessed a primitive instrument analogous to the modern spirit level for determining the horizontal direction.—The Engineer.

CONTEMPORARY ELECTRICAL SCIENCE.*

RADIUM AS A CURATIVE AGENT.—A. Béclère has tested the therapeutic value of radium salts applied externally. He finds that the rays have exactly the same effect as those of a "soft" Röntgen ray tube, and are of little use for deep-seated affections. Their chief advantage lies in the smallness of the apparatus required. A radium preparation is a kind of "pocket edition" of an X-ray tube, and can be applied in places where the latter could not find room.—A. Béclère, Archives d'Electricité Medicale, March 25, 1905.

VARIATION OF DIELECTRIC CONSTANT OF GLASS.—A. Broca and Turchini have found a slight variation of the specific inductive capacity of glass at high frequencies. They found a slight decrease with increasing frequency, but were unable to measure it. They went up to three million periods per second, and used Leyden jars. Consistent results were obtained on putting into the formulæ a capacity amounting to about 0.07 times the capacity of the condenser for ordinary alternating currents.—Broca and Turchini, Comptes Rendus, March 20, 1905.

TRANSMISSION OF ELECTRIC WAVES THROUGH LIQUIDS.—V. Buscemi has, with the help of a modification of Fleming's detector, determined the transparencies of a number of liquids for electromagnetic waves. He finds that acid solutions strongly absorb the waves. If the strength of the penetrating waves is 21 for air, it is 16 for petroleum, 17 for benzine, 12 for ether, 7 for distilled water, 1.5 for a 0.5 per cent salt solution, and inappreciable for concentrated acids or sea water.—V. Buscemi, Nuovo Cimento, February, 1905.

ATMOSPHERIC ELECTRICITY.—G. C. Simpson gives the results of measurements made in the Lapp village of Karasjok, 200 miles south of the North Cape. He got daily curves of the potential gradient extending over a year, and also measured the dissipation, ionization, and amount of emanation. He could not trace the slightest influence of the aurora. The potential gradient had a maximum at 9 P. M. The dissipation was highest at midday in the summer and autumn. For any given wind strength the dissipation is a linear function of the ionization. Both become less in the cold. With rising humidity, the dissipation falls rapidly, and the ratio of negative to positive dissipation increases.—G. C. Simpson, Royal Society, March 2, 1905.

ELECTROMAGNETIC INERTIA.—P. Langevin enters deeper than usual into the connection between electric charge and inertia. He proceeds from the basis of Kaufmann's observation that the mass of the electron is purely electromagnetic—i. e., that its inertia is due to the fact that a change in its motion modifies the energy in the surrounding ether, and therefore either absorbs or emits energy. At a distance from its source an electromagnetic wave contains strictly equal amounts of electric and magnetic energy. This equilibrium can only be disturbed by matter, which acts somewhat like a catalyzer in chemistry. Matter alone can give rise to radiation. The author shows mathematically that the acceleration or retardation of an electron gives rise to a wave which has all the characteristics of an electromagnetic wave, including the quality of electric and magnetic energy. Conversely, all radiation implies change of velocity of electrons. When in steady motion, the electron is accompanied by a "wake" of electromagnetic energy, but this energy does not radiate into infinite space. It is constant, and moves with the electron. Hence Newton's first law of motion, if all matter consists of electrons. The constancy of the inertia of matter enunciated by that law is, however, not universal. It fails when the velocity begins to approach that of light. At that very high velocity, the inertia increases rapidly with the velocity, so that the kinetic energy becomes infinite when the electron moves with the velocity of light. This contingency, however, can only happen once, since P. Hertz has proved that such a velocity must have existed for infinite time if it exists at all. Ordinarily, the energy required to change the "wake" of a slowly moving electron into that of a swiftly moving one is very large compared with the energy radiated at the instant during which the change takes place. Hence the energy radiated can be neglected in ordinary mechanics. But in any system of mechanics based upon electromagnetic theory, the velocity of light must constantly intervene.—P. Langevin, Journal de Physique, March, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

There are 2,962 schools in the Philippine archipelago, an average of 3 for each municipality. Of these, 55 per cent were public, about 33 per cent were private, and the remainder were under the control of the Roman Catholic Church. Of the total enrollment 96 per cent was reported for the primary schools. There are, indeed, only two institutions devoted to higher education. Five per cent of the civilized population of the Philippine Islands is enrolled in the schools. This proportion is only a little over one-fourth of that for the United States, but it represents practically a two-years' growth, as the school system may be said to have commenced with American occupation. One-sixth of all children of school age are enrolled, and three-fourths of that number are in the public schools. The attendance is 62.5 per cent of the enrollment, as compared with 70 per cent in the United States. Boys constitute three-fifths of the pupils in the Philippines, while in the United States the schools are almost equally divided as to sex. Six thousand teachers are employed, four-fifths of whom are Filipinos, receiving an average annual salary of 266 pesos, equivalent to $125.02. This makes the value of 1 peso = 47 cents. The average public school teacher has charge of 73 pupils, while in the United States the number is 36. Of the 3,461 school buildings, the majority of which are public, approximately one-third are built of durable materials. There is great need of additional school facilities and better buildings and equipment, and there is a general demand for an increase in the number of American teachers.

HOW TO MAKE AN OSCILLATING STATIC ELECTRIC MOTOR.

By HOWARD B. DAILEY.

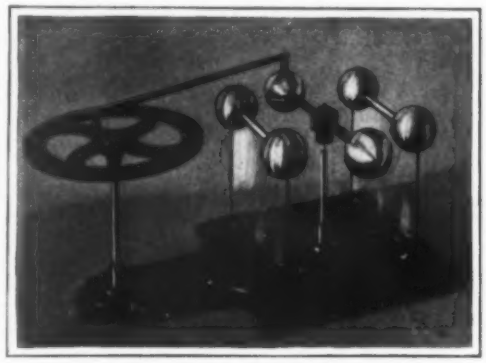
THERE is no adjunct of the influence machine that affords a prettier or more striking experimental demonstration of electrostatic attractions and repulsions than an oscillating static motor.

In view of the dependence of the action of all ordinary types of electric motors upon magnetic influences, the curious little machine here illustrated is truly unique; for though an electric motor in the purest sense of the term, yet it derives its motions from forces that are wholly non-magnetic. With the aid of the working drawings, Fig. 1, and the hints here given, the amateur may easily construct for himself an experimental static motor whose action will be highly gratifying and instructive.

A horizontally oscillating lever, *a*, of round vulcanite rod, carrying at its extremities two hollow balls, *b* and *b'*, of soft pine, communicates its motion through a slender vulcanite connecting rod, *c*, to a light flywheel, *d*, of thin wood. The lever, *a*, passes tightly through a turned wooden hub, *e*, into whose lower end is inserted a pivot rod, *f*, of steel wire, slightly under ⅛ inch in size. The lower portion of *f*, whose end terminates in a sharp point, turns freely in a vertical socket, *g*, rising from the wooden base of the instrument. The flywheel is supported in a similar manner by pivot socket *g'*. These sockets, which are of 5/16-inch round brass rod, soldered into turned brass foot pieces, *n*, are drilled longitudinally in the lathe with a ⅛-inch twist drill to a depth of 2¾ inches. To reduce friction as much as possible, the parts of the pivot rods within the sockets are filed down slightly in their middle so that they may bear against the sides of the sockets for short distances only, near the tops and bottoms of the holes.

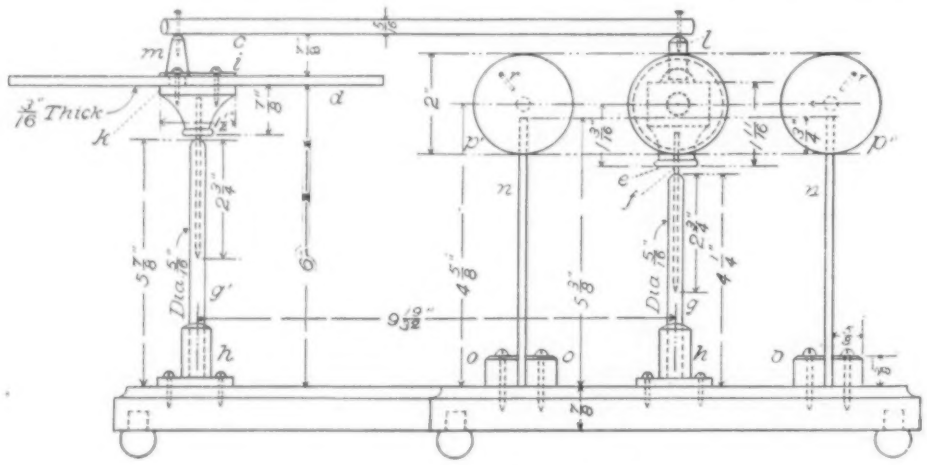
A circular polished plate, *i*, of sheet brass, centrally located on the upper face of the wheel serves to give the latter a finish, and to assist in binding it with small screws upon the turned wooden hub, *k*. Into the ball, *b'*, is inserted vertically a short piece, *l*, of ⅝-inch round wooden rod having a rounded top to reduce the friction between itself and the connecting rod whose end it supports. A round-topped conical wooden crank pin, *m*, rising from the wheel, supports the other end of *c*. The lower end of *m* is turned down slightly and glued into a ¼-inch hole bored through one of the arms of *d* near the hub. The connecting rod, *c*, works freely on two slender wire nails which pass loosely through transverse holes in the rod near its ends and enter *l* and *m* respectively.

On the base of the machine on opposite sides of *g*, and at equal distances from it, are erected vertically, and parallel with each other, two rectangular pieces of double-strength window glass, *n*, each measuring 6⅜ x 5⅜ inches, the glasses being held firmly with shellac between the square wooden cleats, *o*. Upon the upper corners of each glass are cemented with shellac two solid wooden balls, *p* and *p'*, the balls being

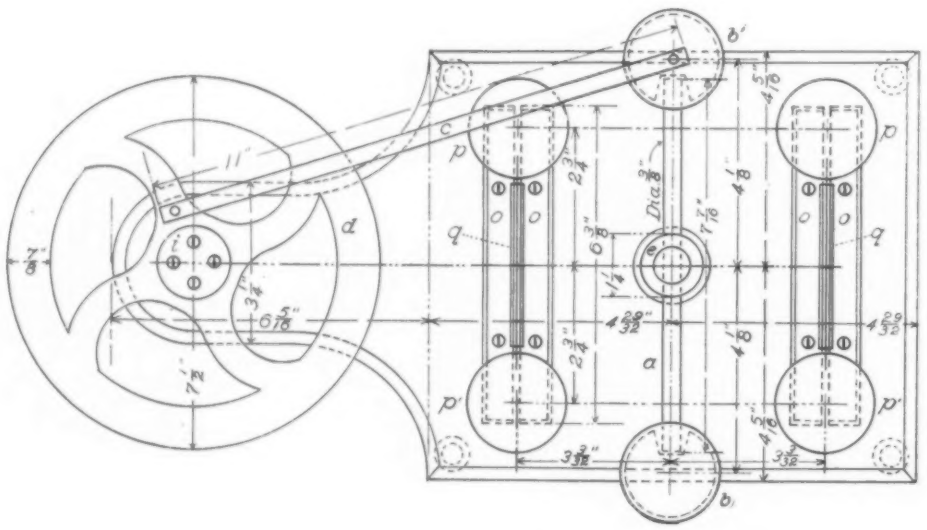


THE STATIC ELECTRIC MOTOR.

slotted to a depth of ¾ inch to receive the glass. The two balls on each glass are electrically connected with each other through a straight stiff wire passing between them, the exposed portion of the wire being covered for purposes of insulation with lengths of glass tubing, *q*. In each of the balls, *p'*, a little above its horizontal center, a small hole, *r*, is bored, somewhat slantingly downward, to receive the ends of the conducting cords or wires connecting the two pairs of stationary balls, respectively, to the positive and negative poles of the static machine. The exact distance apart of the holes in *c*, also the radius of the circle described by the movement of the crank pin, *m*, are not given on the drawing, as it is best to determine these experimentally. The latter should be such as will give about 3/16-inch clearance space between the stationary and the moving balls at the end of the latter's travel. To determine the former accurately, a temporary experimental rod of flat thin wood should first be made. By a few experiments with differently spaced pairs of trial holes in the wooden rod a distance will be found which will evenly divide the clearance room between the stationary and the moving balls at both extremes of the motion of the lever. When the proper distance is found the vulcanite rod may be marked and drilled from the wooden pattern.



SIDE ELEVATION.



PLAN.

HOW TO MAKE AN OSCILLATING STATIC ELECTRIC MOTOR.

The hollowing out of the moving balls, by reducing the weight, adds considerably to the speed of the motor, and is effected as follows: After being bored to a depth of ¾ inch, and fitted to receive the lever, *a*, and the vertical pin, *l*, the balls are neatly split apart through the centers of the bored sockets by carefully driving into them a thin-bladed case knife, which will open them with very little bruising. With a small, sharp gouge each half is hollowed out until its walls are not more than ⅛ inch thick, removing all of the material that can be spared without cutting away the bored sockets. The halves are then glued together again. Before assembling the parts all of the balls must receive a conducting coating of tin-foil. This may be neatly done in the following manner: The ball is first given a sizing of shellac and allowed to dry thoroughly; it is then well smoothed down with sand paper. Next prepare two round pieces of foil about 1½ inch across, slitting each piece inward from its edge for a distance equal to about 1/3 its diameter. A place upon the ball equal in size to that of the foil is now shellacked, as is also one side of the foil itself. Wait a few moments until the varnish has become quite "tacky," then lay the foil in position with the varnished side against the varnished place on the ball and press down into place, allowing the slitted flaps to overlap to prevent undue wrinkling. Proceed in like manner with the second piece, locating it as exactly as possible on the opposite diameter of the ball. The uncovered zone around the equator of the ball is now covered, a piece at a time, with strips of foil reaching across it from one end piece to the other, and as wide as can be applied without excessive wrinkling, varnishing only such portion of the ball at a time as will be covered by the strip to be applied. To avoid too much overlapping of each other at their ends the strips are made somewhat narrower at their ends than at their middle. After the ball is covered all loose corners or edges of foil should be carefully shaved off and any wrinkles or rough places nicely burnished down with a lead pencil or some smooth implement. An almost invisible point left projecting might seriously impair the working of the motor by allowing a silent escape of the electricity into the air. All the working joints must be made sufficiently loose to insure perfect freedom of movement without any possibility of cramping or binding, for it must be remembered that the mechanical forces of static electricity are of a very delicate nature. In operating, to get the best effects, some experimentation will be necessary to ascertain the proper degree of electrification; too vigorous excitation will be found as undesirable as too feeble. If the foregoing conditions have been complied with, the motor will run very satisfactorily from a small Holtz or Wimshurst machine, its speed being about 175 revolutions per minute. The completed machine is shown in perspective in Fig. 2. The action of the instrument depends upon the well-known physical principle of attraction between unlike and repulsion between like electrical states. When covered wires are run from the opposite poles of the generator to the two pairs of fixed balls, the latter become charged, respectively, with positive and negative electricities. The movable balls, being as yet uncharged, are attracted and drawn toward the nearest of the electrified stationary balls, until coming close enough, each moving ball receives a spark and becomes identical in polarity with the ball that has attracted it. Attraction is now instantly changed to repulsion, and the lever begins to reverse its movement. The moving balls, now bearing charges opposite in sign to those of the fixed balls they are approaching, are strongly attracted by the latter, while repelled by those they are receding from. This state persists until the moving balls, gaining fresh sparks of opposite sign to those they first received, have their electrification reversed and are again repelled. A continuous oscillation of the lever with rotation of the wheel results.

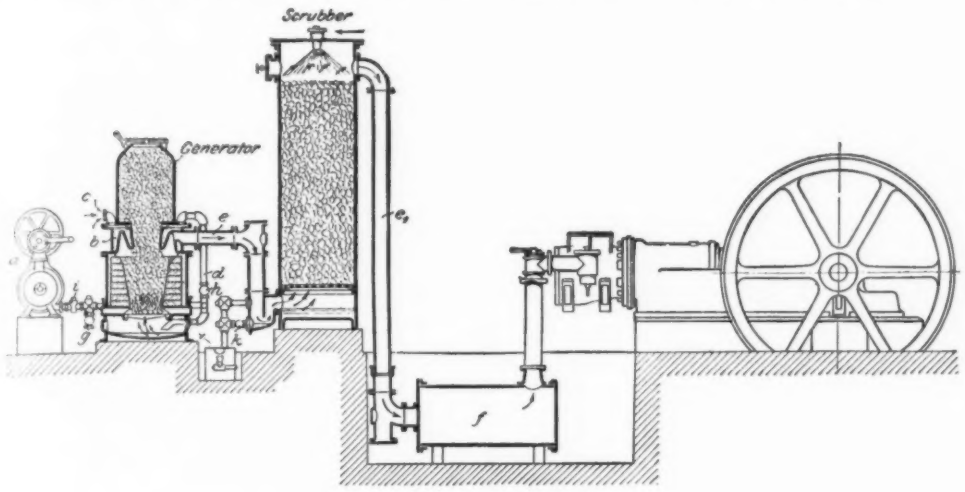
With its crisp-clicking sparks, its general air of brisk activity, and the interesting play of the group of curiously correlated forces visibly demonstrated, the experiment is a most pleasing and attractive one.

OVER-HEATING OF STORED COAL.

THE storage of coal in bulk, in view of the fire danger that it affords under certain conditions, is a subject of some importance to those engaged in many industries. Cases of spontaneous combustion are of frequent occurrence; generally they are caused by improper methods of storage arising out of the prevailing ignorance on the subject. Warmth or damp in a coal heap sets up a slow process of oxidization, and heat that cannot escape being evolved, the effect becomes cumulative, both the oxidization and heat increasing until ignition finally results. Since oxidization is primarily the cause of the trouble, it is evident that the frequently employed system of placing air tubes in the heap is radically wrong, unless the tubes are constructed of such a size as to permit a constant current of air to pass, sufficient in quantity to carry off the heat evolved. As a rule this is not the case, and such tubes are often too small and arranged upon no proper ventilating system, with the result that, instead of producing a draught, they simply convey air to the interior of the mass and thereby assist oxidization. Bituminous and semi-bituminous coals are far more liable to heating than those of the anthracite class; and the more damp, volatile matter and sulphur they contain, the greater is the danger of ignition. 4.75 per cent of water may be taken as the limit that coals of this class should contain, to be safe from undue heating when piled; and should the temperature of the heap attain 140 deg. F.,

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

under any conditions, trouble may be anticipated. A simple and effective method of testing the temperature at the center of a heap consists in ramming an iron rod through to its heart, leaving it there a sufficient time for it to acquire the full heat. Upon withdrawal, an experienced man can tell by his hand if the temperature is dangerous; or a thermometer may be applied to it, the two being enveloped in a handful of waste for a minute or so. The precautions that should be taken against the over-heating of stored coal are simple. It should never be heaped if thoroughly wet, and should be kept in iron or concrete bunkers in a cool place not adjacent to boilers or flues. The pile should never exceed twelve feet in depth, and should be arranged with efficient ventilating spaces round the sides and at the bottom. In the event of combustion or over-heating occurring, the best plan is to turn the coal over thoroughly; pouring water on the top of the heap is of little use, as it may only penetrate sufficiently to make matters worse. If turning over is impossible, and the heart of the pile is suspected to be alight, an effective method is to ram in a good-sized pipe drilled at the end with several holes. When this has penetrated the surrounding coked fuel, a stream of water should be turned on to it, which will speedily result in extinction of the fire.—Technics.



A SUCTION GAS PRODUCER.

SUCTION GAS PRODUCERS.*

By DR. OSKAR NAGEL.

As the economical generation of power is essential for the industries, it undoubtedly will be of interest to the readers of this paper to learn of a new departure in power generation, which makes it possible to generate a power gas for gas engines directly out of coal or coke. As one pound of anthracite or charcoal is sufficient for developing one horse-power hour, it is evident that with a price of $5 per ton for anthracite, one horse-power can be generated for one-fourth of a cent, which is about one-half the cost of steam power.

Producer-gas power plants are built for generating out of a suitable fuel a mixture of carbon monoxide and hydrogen which, if used in gas engines, allows an exceedingly advantageous utilization of the fuel. Up to the present time producer gas has been produced in so-called pressure gas producers by evaporating water in a separate boiler and by leading the steam, mixed with air, by means of a steam-jet blower or fan through the glowing fuel, whereby the steam is decomposed to hydrogen and the coal burned to carbon monoxide. This mixture of combustible gases is led through a scrubber to a gas-holder, and from there to the engine.

It is evident from this description that for generating gas by this method a boiler and a gas-holder are required, which increases considerably the cost of construction and of attendance.

These pressure gas plants are now being superseded by the so-called suction gas producer plants, which are much simpler and cheaper in construction and easy to attend, as no boiler or gas-holder is required.

In a suction gas producer plant the boiler is supplanted by an evaporator, which in small plants is built on the top of the producer, and in large plants right near the producer in the form of a tubular evaporator. This evaporator generates the steam required by utilizing the heat of the producer and of the gases. This is of considerable advantage as compared with the old system; for the firing of a separate boiler is dispensed with, and the heat of the gases produced is used for generating the necessary amount of steam.

The heat of the gases respectively of the producer is entirely sufficient for furnishing such a quantity of steam as is required for the generation of an effective power gas. The utilization of the fuel in suction gas producers is much higher than in pressure producers, and is reaching 80 per cent or more. By leading the steam under the grate the latter is kept cool and clean.

The transformation of steam into hydrogen and the formation of carbon monoxide takes place so quickly that the producer always generates the amount of gas required, and is able to start suddenly from a low to a full load.

A complete suction gas producer plant consists of a producer, an evaporator, an overflow water-pot, a scrubber and an equalizer (sawdust scrubber).

The producer is lined with fire-bricks. By the sucking action of the engine, a mixture of air and steam is drawn through the burning fuel, whereby the producer gas is generated. Only as much gas is generated as is required by the engine. The producer is provided with a hopper, through which fuel can be filled into the producer without interfering with the working of the engine. The cleaning of the grate may be performed during the regular work.

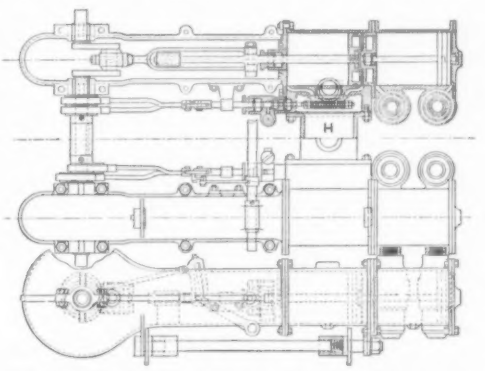
The gas leaving the producer heats up the evaporator and forms steam, which passes under the grate together with the necessary amount of air. From the producer the gas flows through the scrubber, by which it is cooled and purified from the dust and tar. From the scrubber it passes through a small equalizer.

Before starting the engine, the fuel in the producer must be heated by means of a small hand blower, *a*, attached until the gas is burning well. For this about ten minutes is required. When this point is reached, the hand blower is stopped and the engine started in the usual way.

By its own suction the engine is now drawing the necessary amount of air, and is producing power gas. The air enters at *c*, and passes through the evaporator *b*. Here it is saturated with steam, and the mixture of air and steam flows through *d*, under the grate of the producer, through the fuel, and then through pipe *e* to the scrubber; from here through pipe, *e*, to the equalizing tank, *f*, which is directly connected with the engine.

The gas-making process continues as long as the engine is in operation, but as soon as the engine is stopped, gas generation ceases.

Anthracite, charcoal, or coke can be used equally well for generating gas in the suction gas producer. It will take, according to the ash content, 1 to 1 1-3 pounds of anthracite or charcoal, or 1 1-3 to 1½ pounds of coke to develop one horse-power hour. With anthracite (pea) at $5 per ton, one horse-power for 24 hours will cost from 6 to 8 cents. This is about one-eighth the cost of illuminating gas power (at a price of 75 cents per 1,000 cubic feet of illuminating gas) or one-eighth the cost of gasoline (at a price of 16 cents per gallon).



SIX-HORSE-POWER SVEA CALORIC ENGINE.

SVEA CALORIC ENGINE.

By G. EMIL HESSE.

WHEN Capt. John Ericsson brought out his first caloric engine, great hopes were entertained as to its future, but it was soon found that his method of heating the air was too slow for even a moderate volume, without making both size and weight of engine prohibitive. The hot air nearest the heated plates slowly rose into the cooler layers above, thereby gradually heating the whole body of air in the heater. This system has been scrupulously adhered to by the few engineers who have attempted to improve upon the original Ericsson engine.

It is as fundamentally wrong to heat air in this way, as it is to heat water from the surface. The external-combustion engine was therefore practically abandoned when Lenoir discovered a rapid way of doing the same thing by exploding a mixture of gas and air in the cylinder itself.

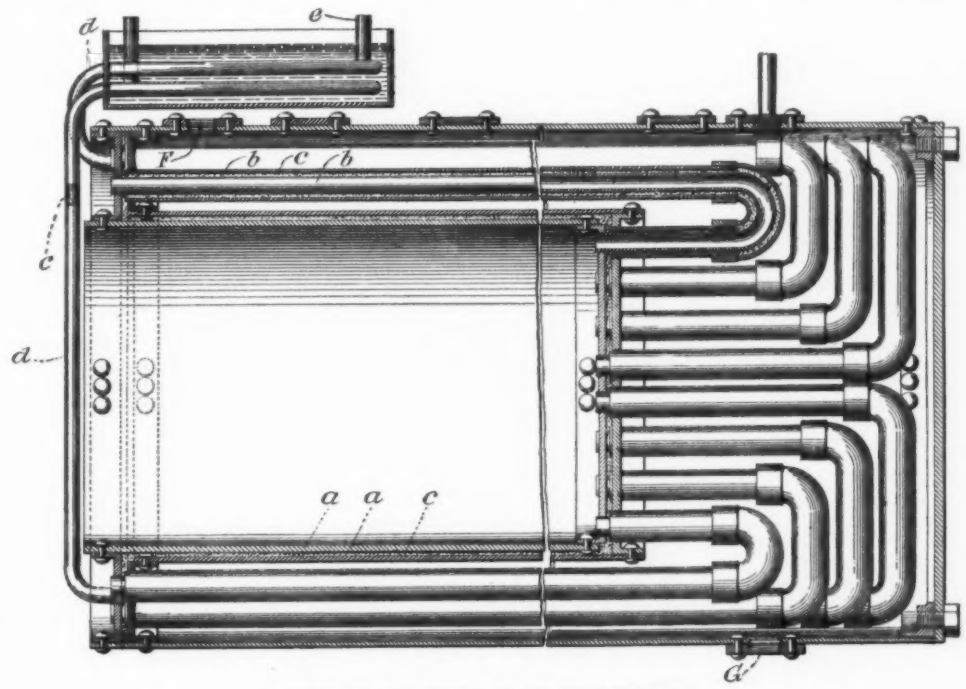
A good many people are under the impression that the expansive force of air is too small to allow its use for large powers, and that this is the reason why only small sizes can be operated with advantage; but they forget that the internal-combustion engine is being built up to 6,000 horse-power, and that is certainly large enough for all practical purposes. The problem to be solved in the external-combustion engine is to heat the air rapidly; the rest will simply be a matter of design, where the engineer's ingenuity will be greatly taxed, but without presenting any insurmountable difficulties.

It is evident that the old method of heating the air must be altogether abandoned for a better and quicker way, without which the external-combustion engine never will be a success.

It is well known that the heated gases generated in the furnace on their way through the boiler tubes give off the heat to the surrounding water in a perfectly satisfactory manner. It is this system, reversed, which has been adopted in the Svea caloric engine.

A 6-horse-power Svea engine now being built has two power cylinders and two air-pumps in tandem with the cranks at an angle of 90 degrees. The air-pump has ordinary poppet valves for the inlet and outlet of the air. The distribution of the heated air in the power cylinder is accomplished by a sliding valve. Means to protect the tubes from burning up must be provided, not so much in the small 6-horse-power engine using oil for fuel as in the large stationary engines, where coal is used.

It is a well-known physical law that water or any other liquid cannot be heated above its melting temperature, as long as a part of it is in a solid state. If,



HEATER OF SVEA CALORIC ENGINE.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

for example, a kettle of water with a piece of ice in it is placed over a fire and heated, it will be found that the temperature is stationary at 0 deg. C., which is the melting point of ice, until the last vestige of it has melted, no matter what the intensity of the fire may be. The Svea heater has double shells, *a*, *a*, in the furnace exposed to the fire, and double tubes, *b*, *b*, between which antimony, *c*, *c*, has been poured. This antimony is extended through the tube, *d*, to a coil, *e*, submerged in water, which will always keep it in a solid state.

Any excess of heat in the furnace will be carried off by the melted antimony to the solid part, which in turn gives it off to the water. The result will be that the air in the heater will have a uniform temperature corresponding with the melting point of antimony, which is 430 deg. C. This metal was selected as the most suitable in order to get the highest practical working temperature.

The working of the engine is as follows: The cold air, drawn from the atmosphere, is pumped into the heater at *F* and forced over the heated tubes, around which it circulates. It is drawn out, thoroughly heated, at *G*, from where it goes to the power cylinder at *H*, and, after doing its work, into the atmosphere.

Large stationary engines from 100 horse-power and upward use air alternately heated and cooled, under a pressure of 100 pounds per square inch, thereby reducing the size of cylinders and other parts, but the same method of heating the air is employed.

It will be seen from the aforesaid that no reliance whatsoever is placed on the mere rising of the hot layers into the cooler above. The air is forced over the heated tubes at a velocity corresponding with the speed of the engine, and with the resultant consumption of heated air in the power cylinders.

The Svea engine is double-acting, self-starting, reversible and as perfectly controlled as a steam engine, which makes it applicable for all work now done by the steam engine.

The weight of the 6-horse-power Svea engine is 450 pounds complete, as compared with 1,700 pounds for the ½-horse-power Ericsson engine. The diameter of both the pump and power cylinder is 4½ inches, the stroke is 4⅞ inches, and the engine makes 450 revolutions per minute. The heater is 20 inches in diameter, 16 inches long, and has a heating surface of 60 square feet.

Many of the large power plants located in cities have to pay more than $100,000 a year for the feed water used in the boilers, whereas air, pure enough to breathe, is always free, which in itself is a saving.

Steam and air at 100 deg. C. are in the same favorable condition for superheating. With 10 deg. C. as the initial temperature for both water and air, we find that the expenditure of heat necessary to raise the water to 100 deg. C. is 90 thermal units. The amount of heat required to convert it into steam of 100 deg. C. is 537 units, making a total per kilogramme of $90 + 537 = 627$ thermal units. The same weight of air requires $90 \times 0.24 = 21.6$ thermal units. The saving accomplished by condensing the steam is:

$$\frac{10334 \times 1.649}{424\,(\frac{1}{0.5} - 1)}\left[1 - \left(\frac{1.649}{14.55}\right)^{\frac{1}{5}}\right] = 79 \text{ units.}$$

The total net expenditure of heat, which in this instance is an absolute loss, is, consequently, for steam under the most favorable conditions, $627 - 76 = 551$ thermal units, as compared with 22 units for the air.

One kilogramme of coal contains 7,200 thermal units and evaporates 8 kilogrammes of water.

The best triple-expansion steam engine has an efficiency of 14 per cent, equal to $0.14 \times 7,200 = 1,008$ thermal units. The heat lost by the evaporation of the water per kilogramme of coal is $8 \times 537 = 4,296$ units; the rest, 1,896 units, is lost through the chimney or by radiation, friction, etc.

Most of these 4,296 units are converted into power by the Svea engine in addition to the 1,008 units, which will make it the most efficient engine on the market.

The heat radiating surface of heater and cylinders is not larger than in a steam plant. The heated gases generated in the furnace are utilized in the same economical manner as in a steam boiler, thereby placing the two powers on an equal basis as far as the utilization of the heat itself is concerned. No cooling water is needed for the cylinders, as the air cannot exceed a temperature of 430 deg. C., thereby doing away with one of the largest losses experienced in the gas and oil engine.

The theoretical efficiency for this engine with the air at 430 deg. C., and the exhaust at 40 deg. C. is:

$$1 - \frac{273 + 40}{273 + 430} = 0.56 = 56 \text{ per cent.}$$

Claims are often made for the rotary engine, and even the steam turbine, that they will accomplish a large saving, but it is safe to say that at best it is insignificant. The turbine has other important advantages, both in regard to decreased bulk and weight, which make it popular. The efficiency of a reciprocating engine is as high as 90 per cent, when the steam once gets into the cylinder, and it is difficult to improve much on such perfection. The leak should not be looked for in that direction.

The great loss, overshadowing every other imperfection, which the steam engine has as an economical transmitter of heat into power, is the tremendous amount of heat lost in converting the water into steam, and this is fully realized by the advocates of the hot-air engine, both of the internal and external combustion type.

[Commenting on this engine in a letter published in the Railroad Gazette, Mr. Sidney A. Reeve, of Worcester, Mass., has this to say: "Assuming an atmospheric temperature of 59 deg. F., and that the motor-cylinder would receive the air at a temperature of 600 deg. F., which is quite as high as safe practice permits in steam-engine cylinders, the maximum theoretical efficiency possible is 31 per cent, and the maximum theoretical power developed would be 1.45 horse-power. Since good engineering practice usually develops only some 60 per cent of the theoretical efficiency on the piston, it is safe to say that this engine will not go beyond 69 per cent. This means 21 per cent indicated efficiency and 1.00 horse-power on the piston, or not enough to cover the probable friction of the machine. This is the old story with this type of engine, which has been repeated many times since 1825; fine theoretical efficiency, but no power. It will continue to be repeated until designers in this field learn to compete with the internal-combustion engine upon terms of equality; that is to say, with working-pressures equal to those of their rivals."]

HOW TO REMEMBER THE WIRE TABLE.*

By CHARLES F. SCOTT.

THE wire table for the B. & S. gage copper wire has a few simple relations, such that if a few constants are carried in the memory the whole table can be constructed mentally with approximate accuracy.

Resistance.—A wire which is three sizes larger than another wire has twice the weight and half the resistance.

No. 10 wire has a resistance of 1 ohm per thousand feet; No. 7 wire, which is three sizes larger, has 0.5 ohm per thousand feet; No. 4 wire, which is three sizes larger than No. 7, has 0.25 ohm; No. 13 wire, which is three sizes smaller than No. 10, has 2 ohms; No. 16 wire, which is three sizes smaller than No. 13, has 4 ohms. It is easy, therefore, knowing the resistance of No. 10, to find the resistance of No. 7, No. 4, No. 1, and No. 000; also of No. 13, No. 16, No. 19, etc.

A wire which is ten sizes larger than another wire has ten times the weight and one-tenth the resistance.

As the resistance of No. 10 is 1 ohm per thousand feet, the resistance of No. 0 is 0.1 ohm, and the resistance of No. 20 wire is 10 ohms. As the resistance of No. 4 is 0.25 ohm, the resistance of No. 14 is 2.5 ohms and of No. 24, 25 ohms.

In the following table the first column contains the sizes of wire which differ from one another by three sizes. The resistance of each wire in this column is seen to be twice that of the next larger size and one-half that of the next smaller size. There is, therefore, no difficulty in remembering this column. In the second division of the table the wires are ten sizes smaller than those in the first division; thus No. 11 corresponds to No. 1, and the resistance is ten times as great. In the third division of the table the wires are ten sizes larger than those in the first division; thus No. 0 corresponds with No. 10 and the resistance is one-tenth as great.

Size.	Ohms.	Size.	Ohms.	Size.	Ohms.
No. 1	.125	No. 11	1.25		
No. 4	.25	No. 14	2.5		
No. 7	.5	No. 17	5	No. 0000	.05
No. 10	1	No. 20	10	No. 0	.1
No. 13	2	No. 23	20	No. 3	.2
No. 16	4	No. 26	40	No. 6	.4
No. 19	8	No. 29	80	No. 9	.8
No. 22	16	No. 32	160	No. 12	1.6
No. 25	32	No. 35	320	No. 15	3.2

From this table several new relations may be observed.

If the wire is one size smaller the resistance is 25 per cent greater. For example: Compare No. 11 with No. 10, No. 12 with No. 11, No. 13 with No. 12, etc.

If the wire is two sizes smaller the resistance is 60 per cent greater. For example: Compare No. 12 with No. 10, No. 16 with No. 14, No. 15 with No. 13.

If the wire is one size larger the resistance is 80 per cent of that of the smaller wire. For example: Compare No. 9 with No. 10, No. 10 with No. 11.

If the wire is two sizes smaller the resistance is 60 per cent of that of the smaller wire. For example: Compare No. 11 with No. 13, No. 4 with No. 6.

From the foregoing the following are the ratios of resistance between wires of consecutive sizes:

0.50, 0.63, 0.80, 1.00, 1.25, 1.60, 2.00.

Weight.—The weight of a wire is inversely proportional to its resistance. Therefore, the foregoing relations are the same for weight as for resistance, excepting that the weights increase as the size of the wire increases, instead of diminishing. The weights of successive sizes of wire, therefore, bear the following relation, beginning with the smaller wire:

0.50, 0.63, 0.80, 1.00, 1.25, 1.60, 2.00.

If the weight of any size of wire is known, it is therefore seen that the weight of the next larger size is 25 per cent greater; the weight of the second larger size is 60 per cent, and the weight of the third larger size is double; also, the weight of the sixth larger size will be four times as great, and the weight of the tenth larger size will be ten times as great.

The weight of 1,000 feet of No. 10 copper wire is 31.4 pounds. Therefore, the weight of No. 7 wire is 62.8 pounds; the weight of No. 0 wire is 314 pounds. The weight of No. 5 wire is 100 pounds per thousand feet, which is a convenient figure to remember. The weight of No. 2 wire is, therefore, 200 pounds, and the weight of No. 00 wire is 400 pounds.

Area.—The area of No. 10 wire is approximately 10,000 circular mils (more precisely 10,380). The area is proportional to the weight. The area of No. 7 wire is, therefore, about 20,000 circular mils, of No. 0 wire 100,000 and of No. 0000 wire 200,000. The precise area of No. 10 wire is 10,380 circular mils. Taking this figure for easy calculation as 10,400 and following the process above indicated, the area of No. 0000 wire is found to be 208,000, which is very nearly 211,600, the figure in the wire table.

Diameter.—The diameter of No. 10 wire is approximately 0.10 inch (more precisely 0.102 inch). The diameters follow the same ratio as the circular mils and weights except that this ratio applies to alternate sizes. Therefore the sixth smaller size has half the diameter and the twentieth smaller size has one-tenth the diameter. Therefore, as No. 10 is 0.10 inch, No. 16 is 0.05 inch and No. 30 is 0.01 inch; also No. 4 is 0.20 inch, and No. 000 is 0.40 inch; also No. 0 (two sizes smaller than No. 000) has 80 per cent less diameter, or 0.32 inch. No. 00, lying between these sizes, may be presumed to be about 10 per cent less than No. 000, or 0.36 inch; the diameter given in the wire table is 0.3648.

Reference to a complete wire table will show that the figures in the above examples and other figures which may be determined in the same way are correct within a few per cent. A little practice in mental arithmetic will enable anyone to determine the approximate weight and resistance of wire of any size.

Summary.—The things to be remembered regarding B. & S. gage copper wire are the following:

A wire which is three sizes larger than another wire has half the resistance, twice the weight and twice the area. A wire which is ten sizes larger than another wire has one-tenth the resistance, ten times the weight and ten times the area.

No. 10 wire is 0.10 inch in diameter (more precisely 0.102); it has an area of 10,000 circular mils (more precisely 10,380); it has a resistance of 1 ohm per thousand feet at 20 degrees Centigrade (68 deg. F.), and weighs 32 pounds (more precisely 31.4 pounds) per thousand feet.

The weight of one thousand feet of No. 5 wire is 100 pounds.

The relative values of resistance (for decreasing sizes) and of weight and area (for increasing sizes) for consecutive sizes are:

0.50, 0.63, 0.80, 1.00, 1.25, 1.60, 2.00.

The relative values of the diameters of alternate sizes of wire are:

0.50, 0.63, 0.80, 1.00, 1.25, 1.60, 2.00.

Circular Mils.—Conductors of large size are usually specified in circular mils. For example, 500,000 circular mils, 750,000 circular mils.

As No. 10 wire has approximately 10,000 circular mils and a resistance of 1 ohm per thousand feet, and as the length of a wire which has a given resistance is proportional to its area, it follows therefore that the length in feet of a copper conductor having a resistance of 1 ohm may be found by dropping one cipher from the number expressing its circular mils. For example, No. 10 wire has 10,000 circular mils and a resistance of 1 ohm per 1,000 feet; a 300,000 circular mil conductor has a resistance of 1 ohm per 30,000 feet, and a 1,000,000 circular mil conductor has a resistance of 1 ohm per 100,000 feet. The weight of a given length is proportional to the area; therefore, the weight of a conductor having 500,000 circular mils is greater than that of No. 10 wire in the same ratio that its area is greater. Five hundred thousand circular mils is fifty times that of No. 10 wire or approximately fifty times 32 pounds, which equals 1,600 pounds per thousand feet. In this way the approximate characteristics of copper conductors of all sizes may be quickly ascertained.

To find resistance, drop one cipher from the number of circular mils; the result is the number of feet per ohm.

To find weight, drop four ciphers from the number of circular mils and multiply by the weight of No. 10 wire.

* Electric Club Journal.

LENGTHENING OF ARMORED CONCRETE.

IN a paper recently presented to the French Academy of Sciences, Mr. Considère takes up again the problem of the lengthening capacity of armored concrete. In previous papers the author had brought out some facts which were accepted by many engineers as the foundation of the theory, while others would look at them with diffidence. In fact, both German and American experimenters were able to show since Considère's researches that reinforced concrete prepared under their supervision cracked under the same breaking tension as the non-reinforced material, whence they inferred that very minute fissures had actually been produced in the concrete, but on account of their smallness had escaped the author's attention. The author accordingly proceeded to make an extensive series of tests on two concrete beams 3 meters in length, which were prepared without any special precaution from concrete including 400 kgs. of Portland cement, 400 liters sand, and 800 liters lime gravel, the amount of water being 9.6 per cent of the weight of the dry material. The reinforcement consisted of two soft-steel bars, 60 millimeters in diameter, and three bars of 12 millimeters diameter being arranged close to the surface submitted to the greatest tension. One of these beams was kept in a moist condition by frequent sprinkling, and submitted to tension some months after having been prepared, about one month before the other beam, which had been kept immersed under water during all that time. Placed on supports 0.05 meter distant from their ends, they were subjected to hydraulic pressure at two points situated symmetrically at 0.70 meter on either

side from the middle, so that over a length of 1.40 meters the bending moment was constant and the shearing force *nil*.

In the middle of this length the tension of the surface under stress was observed over a length of 1.02 meters by means of two microscopes mounted on the same rail, the shortening of the compressed portion being measured over a length of 0.50 meter by means of two Mesnet-Rabut apparatus placed on the lateral surfaces.

The loading was stopped at the moment when the tension of the outer fibers of the concrete was 0.625 millimeter with the first and 1.300 millimeters with the second beam, when under the microscope no fissures were observed in the coating of pure cement, which, in order to facilitate observations, had been applied on the surface.

The concrete covering the reinforcement was afterward chiseled off, and the reinforcement withdrawn, after which the surface of the concrete was smoothed down as far as possible. The upper portion was then removed with a saw. When tracing the diagram of deformations, it was seen that the various fibers of portions thus removed had undergone tensions lying between 0.22 millimeter and 0.50 millimeter with the second beam, while non-armored concrete is known to break as soon as its tension exceeds 0.10 millimeter to 0.20 millimeter.

The same plates were also submitted to bending tests, when they were found to possess a high resitivity. For the sake of comparison, the other parts of the same beam were tested in the same way, and the strength found to be of the same order, viz., about 30 to 35 kilogrammes.

From all this it would appear that not only can properly prepared reinforced concrete stand tensions of far greater value without breaking than non-reinforced concrete, but that after considerable deformation, the material still possesses a tensile strength comparable and may be equal to that of concrete having undergone no previous deformation.

As, however, reinforced constructions according to the author are liable to show fissures due to their shrinkage after being prepared, the reinforcement should be given sufficient cross section, so that it may stand the whole of the load, while an accurate knowledge of the non-elastic deformation of armored concrete is likewise indispensable.

RAILROAD TIES OF LOPLOLLY PINE.

A good example of what is being done along the most practical lines by the Forest Service, is furnished by the results of a study of loblolly pine in east Texas which it has recently made. Vast quantities of loblolly pine exist in the Southern States, some of which is sold on the market as short-leaf yellow pine. The wood of loblolly pine is inferior to that of long-leaf and of short-leaf pine, partly because of the rapidity with which it decays when exposed to the weather or in contact with the soil, but for many purposes it answers just as well as the more valuable species. It is certain to increase greatly in commercial value and its use is now extending rapidly. As the long-leaf and short-leaf pines become scarcer and higher in price loblolly is sure to replace them to a great extent; this study of its uses is therefore very timely.

One of the chief purposes for which loblolly is now used in the Gulf States is for railroad ties. The wood is not durable and the tie in its natural state is short-lived, but by preservative treatment it can be made to resist decay for a number of years. The discovery that treated loblolly pine is an excellent substitute for long-leaf for railroad ties is greatly to the benefit of the railroads since it enables them to use a less expensive tie. It also benefits the country at large by cutting off one of the heavy demands made upon the long-leaf forests and thereby setting free a corresponding amount of that material for the general market.

In making loblolly pine ties there are many wastes and the drain upon the existing forests is greater than it need be. The recent study was therefore made for the purpose of showing the rate of growth of the trees, and how ties could be produced more economically.

Loblolly pine is found in commercial quantities in ten counties of east Texas, where it covers an area of nearly 2,880,000 acres, and is hewn into cross-ties on a larger scale than in any other State. The magnitude of this industry results from an abundant supply of loblolly pine of sizes just suited for pole ties. It is estimated that from 75 to 80 per cent of the present loblolly stand in Texas is timber of tie size, the remainder being large enough for lumber. The preponderance of comparatively young and small timber is due principally to severe storms in 1865 and 1873 which overthrew the old pine on many thousands of acres and established new stands of young trees.

Loblolly is adapted to a wider range of soils than any other pine in east Texas. This, with its frequent and prolific seeding, its rapid rate of growth, and its immunity from hogs which eat the roots of the young long-leaf pine, enable loblolly pine to reproduce readily on denuded land. In many situations it competes successfully with long-leaf pine and comes up under hardwoods if the stand is not too dense, and rapidly outgrows them. The conditions in east Texas are most favorable to this species; it is sure to increase in commercial importance and may become the principal source of timber supply of the region.

Three counties in east Texas—Orange, Jasper, and Newton—furnish annually from 1,000,000 to 1,500,000 hewn loblolly pine ties. The trees cut for ties vary in size from 11 to 17 inches in diameter, measured breast high. The hewers prefer diameters of 12, 13, and 14 inches, as the smaller the tree, above tie specifications, the less the labor in squaring it. The largest number taken are 13 inches in diameter. This practice is very wasteful, for the average tree 11 inches in diameter is about thirty-five years old and is growing rapidly. The average yearly increase in value between 11 and 13 inches is over 7 per cent, and from 13 to 14 inches 5.5 per cent. After the latter size is reached growth falls off so fast that for the next inch of growth the increase averages only 2.5 per cent, and at 16 inches the value for hewn ties ceases to increase.

These facts point out the rule which the owner should follow in selling trees for ties. Those 11, 12, and 13 inches in diameter are growing so rapidly both in size and value that to cut them consumes the capital that is bringing him the best rate of interest. The tie maker should be confined to 14, 15, and 16-inch diameters. Trees above 16 inches should be preserved until they can be profitably felled for lumber.

The adoption of this rule will be best for the owner and for the productive future of the forest as well. It will however necessitate a complete change in the method of getting out ties as they will have to be sawed instead of hewed. But this, too, would be a gain for both owner and forest, since hewing is a very wasteful method of tie production. Under it many of the larger trees are cut with unnecessarily high stumps in order to save labor in hewing down the butts. In many other cases the trees are not used as far up into the tops as they might be. Further, the hewing process itself is very wasteful and leaves in the woods a quantity of litter in the shape of slabs and chips in which fire is often started and the forest seriously damaged.

If hewing is continued it would be unwise to restrict the cutting to 14, 15, and 16-inch trees, for that would involve increased waste, but the value of the smaller sizes demands this restriction, and sawing should take the place of hewing. When the larger logs are sawed several boards can be obtained from the wood now wasted in slabs and chips as the hewing progresses.

There is still another form of waste resulting from hewing. In grading ties the railroads are very strict about accepting none under specification sizes, but they do not object to some excess in size. This, and the fact that less labor is required to produce large ties, has induced hewers to make many ties larger than they need be. This is a small matter in the case of each tie, but as they are cut by the million the excess represents in the total a very large waste of wood. It means also an unnecessarily great consumption of creosote or other material used in the preservative treatment, since the total bulk of wood which must be treated is greater.

It is estimated that from 48 to 70 per cent of the timber cut for pole ties goes into chips, slabs, and excess over the maximum dimensions required. Adding all causes of waste it is found that the percentage of timber actually used in hewn ties is no more than from 25 to 30 per cent of the total volume of the trees felled.

Loblolly pine grows so rapidly that two crops of pole ties can be produced in less time than is required to grow one crop of long-leaf pine ties, and from each of the two crops there will be a larger average yield of ties. This tremendous advantage of loblolly pine is increased by the marked ability of the tree to reproduce itself. Conditions in east Texas are almost ideal for the maintenance of forests of this tree, and the opportunity to earn good returns by their conservative management is equaled in few parts of the country.

HUXLEY, AND NATURAL SELECTION.

ON March 23, Prof. E. B. Poulton, F.R.S., delivered the Huxley lecture at Birmingham. He said the attitude of Huxley toward natural selection was remarkable and unusual. Although no one fought so nobly, and against such odds in its favor, although no one had ever fought the battle of science with such success, Huxley was never a convinced believer in the theory he defended from unfair attack. At least one cause of that want of confidence he (the lecturer) believed to be due to the fact that his researches, determined by the bent of nature, were anatomical and palæontological rather than the study of the living organism in relation to its environment, and especially its living environment. The origin and growth of the theory and the circumstances under which it was made public had often been told. Darwin, convinced of evolution by reflection upon his observations in South America during the voyage of the "Beagle" (1831-36), began in July, 1837, systematically to collect facts bearing upon the modification of species and its causes. In October of the following year he read Maithus "On Population," and the idea of natural selection at once dawned on his mind. In June, 1842, he wrote a brief account of the theory, and two years later an essay; but he could not be induced to publish until, on June 18, 1858, almost exactly twenty years after the conception first came to him, he received a manuscript essay written by A. R. Wallace in the Moluccas "On the Tendency of Varieties to Depart Indefinitely from the Original Type." Darwin placed himself in the hands of his friends Lyell and Hooker, who asked for an abstract of his own work, and presented it, with Wallace's essay, to the Linnean Society on July 1, 1858. Now that we knew the circumstances under which Wallace wrote his essay, the coincidence was far more striking. He also was convinced of evolution, and had written a powerful paper in support of it. But he knew of no motive cause until, in February, 1858, lying ill of fever in Ternate, he began to think of Malthus's book, and the idea of natural selection instantly flashed across his mind; but he did not wait 20 years. In two hours he had thought out almost the whole of the theory, in three evenings he had finished it, and he sent it to Darwin. Thus, on July 1, 1858, when Darwin was nearly 50 and Huxley just over 33, the great theory was before the world, and the most striking thing about Huxley in relation to it was the fact that he knew nothing about it. Almost exactly a year after the appearance of the paper on June 25, 1859, he wrote to Lyell in favor of the transmutation of species, but against the idea of transition between species. The letter showed that he had no notion of natural selection, but only of changes wrought by external conditions, changes sudden and sharply marked off, like those which follow the replacement of one chemical element by another in a compound—to use his own metaphor. "The Origin of Species" was published in November, 1859, and an advance copy was sent by Darwin to Huxley. In his chapter on the reception of "The Origin of Species" ("Life and Letters of Charles Darwin," Vol. II.) Huxley said: "My reflections when I first made myself master of the central idea of the 'Origin' was how extremely stupid not to have thought of that"—further evidence that he had known nothing of the details of the Linnean Society paper, where the central idea was admirably, although, of course, briefly, explained by its discoverers.

Huxley's want of knowledge of natural selection in the interval between July 1, 1858, and the end of November, 1859, suggested several interesting reflections. Great and original workers rarely had the time for wide reading in their subject away from the lines of their special investigations. They were also held back by the feeling that the attempt to be encyclopædic was itself destructive of originality, and yet there was nothing so inspiring to a young worker as the fact that his attempts had interested a great and original worker in his own subject. The position looked like a dilemma, but the escape was easy. But if the antagonism between the excessive cultivation of the memory and the development of originality was seen in the lives of older men, whose capacity for the highest work was proved and certain, surely conclusions of value were to be learned from those whose duty it was to watch over the developing mind of the young. A little knowledge was said to be a dangerous thing; but as regarded the awakening and growth of the most indispensable part of our intellectual equipment—the imagination—it might be more truly said that a great deal of knowledge was a dangerous thing. With the very best intentions, but with the very worst results, the idea had taken root in this country that the imagination must not be allowed free play until some arbitrary amount of knowledge had been imbibed, and the result was that too often all original faculty was water-logged and drowned in a sea of facts. Returning to Huxley's independent views on evolution, which were what we should expect from a great student of animal structure rather than of animal life, who was at the same time a profound and cautious thinker, he said that Huxley told us that before the appearance of the "Origin" he took his stand upon two grounds—first, that up to that time the evidence in favor of transmutation was wholly insufficient; and, secondly, that no suggestion respecting the causes of the transmutation which had been made was in any way adequate to explain the phenomena. And yet all along there was alive in him a sort of pious conviction that evolution would turn out true, and the kind of evolution he imagined was, so far as we were able to judge, a conception which would arise in the mind of one who compared animal structures with the eye and brain of the inquirer rather than of the naturalist. At the age of twenty-six he wrote to W. S. Macleary: "I am every day becoming more and more certain that you were on the right track thirty years ago in your views of the order and symmetry to be traced in the true natural system." Macleary's ideas of the grouping of the animal kingdom were about as regular and symmetrical as the figures seen in a kaleidoscope. And a conception of sharply separated mathematically grouped forms would naturally lead to the idea of evolution by sharp and abrupt steps, whereby a new form would appear by sudden transformation of the old, just as a chemical compound changed when one element in it was replaced by another.

The evidence led to the belief that that was the state of Huxley's mind when, in November, 1859, he read the "Origin." He there met with far more convincing proofs of evolution than he had ever encountered before, and he accepted them at once, unreservedly, permanently. He furthermore encountered what was to him the entirely new idea of natural selection, and he recognized that it disposed of his earlier objection that no motive cause in any way adequate had been suggested. But to the end of his life he never went beyond that. He never committed himself to a full belief in natural selection, and even contemplated the possibility of its ultimate disappearance. The difficulty which he felt early and late, and about which he had a prolonged discussion with Darwin, was the fact that the breeds created by the artificial selection of man were mutually fertile, while the species created *ex hypothesi* by natural selection were mutually sterile. Without going into the controversy, it might be said that, according to Darwin, Huxley's objection merely meant that the results of an experiment prolonged for an immense period were not in every respect the same as those attained when it endured for a time comparatively brief. Other students felt a confidence in natural selection which was not shared by the great leader, as it required the student of living nature to discover the principle itself. The experience

which brought confidence in it was that mainly of the naturalist, and the strongest confidence in the abiding truth of a theory was gained by those whose imagination had been inspired by it. Every verified prediction made by the light of natural selection placed the theory upon a more secure foundation. That foundation had been growing more secure for nearly half a century; but, as Prof. Poulton showed in conclusion, that increasing confidence was not so much due to the facts which were the province of the anatomist as those which formed the every-day experience of the naturalist, of the man who studied animal form and change and instinct, not in relation to the single individual or the single species, but in relation to the whole environment, and especially the living environment. That kind of study did not appeal to Huxley's nature, and therefore the confidence in natural selection, of which the lecturer had spoken, was not for him; but those who felt it should never forget how much they owed to Huxley for the leading part he took in the great battles which had to be fought before evolution and natural selection were accorded a fair hearing; and his success went far beyond even those issues. Whatever stirring and subversive ideas the future might be preparing for us, we might be sure that they would never suffer from the treatment accorded to the "Origin of Species," and far more than to any other single man the world owed that immense gain to Huxley.

NEW APPARATUS FOR RECORDING THE VIBRATION OF RAILWAY CARS.

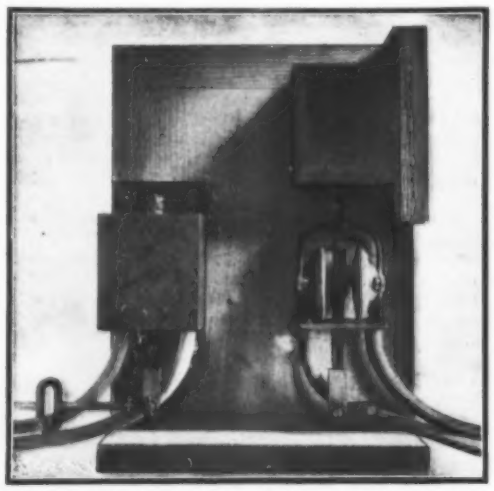
By EMILE GUARINI.

M. SABOURET, engineer-in-chief of rolling stock and traction of the Railways of the West, at Paris, has recently devised a very interesting arrangement for the study of the secondary motions that occur in a vehicle while running, that is to say, the relatively irregular motions that are observed between the pieces that are not invariably connected, as, for instance, the fluctuations in the bend of a spring, the displacements of an axle journal in its box, the two motions in a horizontal plane taken on by a free axle, with respect to the frame, etc. A cinematic study of these motions leads to a measurement of the linear oscillations, which is effected by means of a "linear explorer." But there are other parasitic motions that are produced during the running of a vehicle, such, for example, as transverse or vertical shocks. Such shocks are characterized by the velocity of the mass in motion at the extreme end of its travel or moment at which the shock occurs. This velocity is measured by means of a "ballistic explorer."

The apparatus, collectively, comprises three essential parts, viz., the explorers, which are mounted upon the pieces to be studied; transmissions; and one or more registering devices. One registering apparatus usually suffices for inscribing upon the same sheet the indications furnished by the explorers.

The transmitting arrangement employed is a pneumatic one of the Marey type and is formed of two small brass drums closed by a sheet of rubber, and connected with each other by a tube. Any displacement of the center of the rubber of the exploring drum causes a proportional displacement of the center of the rubber of the registering drum. The motion of the first rubber, amplified by a lever, is inscribed by a pen upon the paper that unwinds in front of it.

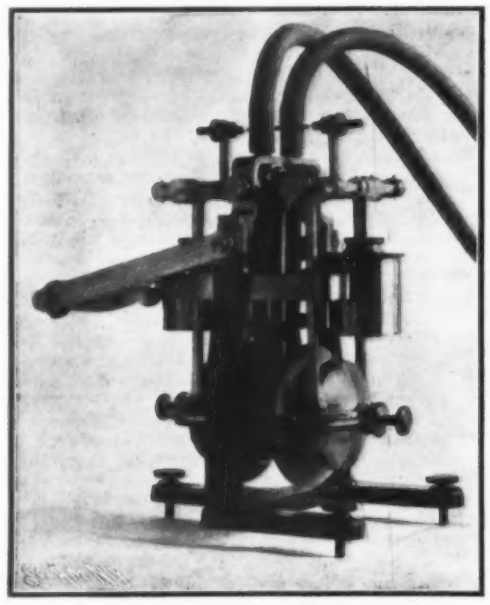
The linear explorer consists essentially of a lever pivoted to an inverted U-shaped frame that is clamped to the upper side of a rectangular protecting box. The



PNEUMATIC VIBRATION TRANSMITTER.

frame contains two similar pneumatic drums, the rubber diaphragms of which are connected in the center by a small rod. Every angular displacement of this connecting rod produces an expulsion of air from one of the drums and a suction in the other. The drum is a brass box in the form of a truncated cone, the wide base of which is closed by sheet rubber. The enveloping box is provided with lugs by which it is secured to the piece to be studied.

The external point of which the relative displacements are to be noted is connected by a rod with the end of the lever. Only one of the drums is utilized in the study of an isolated motion. The second is used either when it is desired to register simultaneously the motion considered and its combination with a second motion, or when it is desired to counterbalance the variations of temperature. As a general thing, such variations are very slow with respect to the motions studied, and so it suffices to now and then bring the registering pin back to zero by causing the tube to communicate with the atmosphere. If it is desired to eliminate this disturbing influence in certain experiments, recourse is had to the Hervé-Mangon differential arrangement. In this the oscillating point acts upon



APPARATUS FOR REGISTERING SHOCKS.

two conjugate exploring drums, of which the tubes, of the same length and arranged beside each other, end at two registering drums that are suitably placed. Such a system is necessarily non-sensitive to the variations in temperature.

If it be desired, for example, to mount two linear explorers upon a car truck, the box of one of the explorers is fastened to the body of the car and that of the other to the frame of the truck. An angle brace fixed to the oscillating crosspiece serves as an external point of the latter. One axle is connected by two rods with the two lever ends of the two explorers. The first explorer indicates the movement of the truck with respect to the car body, and the second the transverse oscillations of the crosspiece with respect to the frame or truck. Slides formed at the extremities of the first of the two above-mentioned connecting rods serve to relieve the second explorer from the displacements produced by the rotary movement of the truck.

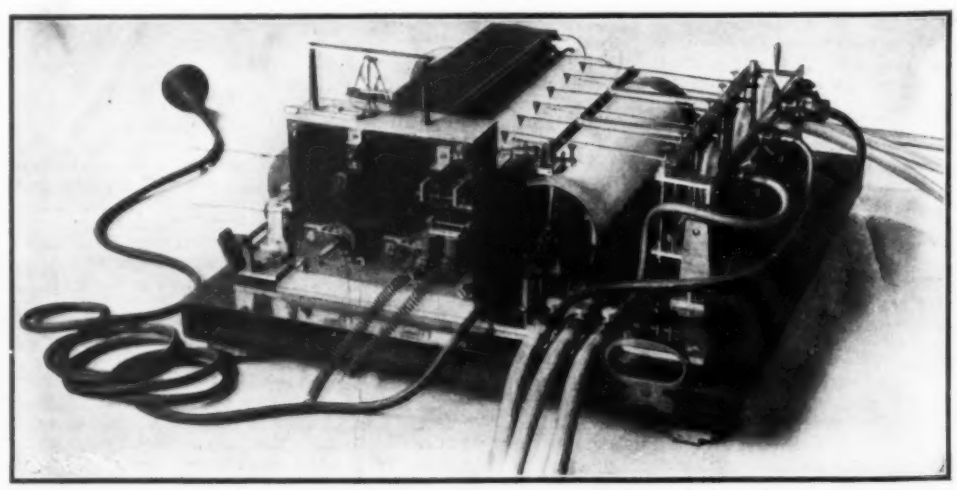
We now come to the ballistic explorer. This apparatus consists essentially of two pendulums bearing in their vertical position, through one spring in common, against a frame that carries their axes. A sudden displacement of the frame from left to right, followed by an abrupt stopping of it, sends to the right one of the pendulums, which immediately swings back through its own weight and a spring upon the buffer of the frame. The amplitude of the swing of the pendulum measures within certain limits the velocity acquired by the frame at the end of the shock. The transmission of the angular deflection of the pendulum to the registering apparatus is effected by one of the two pneumatic drums, as in the linear explorer. One of the two pendulums registers shocks toward the right, while the other, arranged symmetrically, registers those toward the left. It is indispensable to deaden the motion of each pendulum at the central point of each oscillation, since, in practice, the shocks of a vehicle under way succeed each other too rapidly to allow the pendulum to resume, of itself, its position of equilibrium between two consecutive shocks. The characteristic oscillations of the pendulum would then be added to the effects produced by the motions of the apparatus. The result will be entirely otherwise if the pendulum be deadened in its vertical position by a buffer, and can move therefrom in one direction only, since it is impelled with the velocity that the system possesses at the moment of the shock. The amplitude taken on by the pendulum thus projected will measure the velocity of the system at the time of the shock, provided that the contrary motion of the system be not instantaneous and the pendulum have time to reach the end of its travel before the beginning of the recoil. If, in fact, the recoil of the system begins while the pendulum is moving again from the vertical, it will involve the suspension axis of the latter, and such displacement, combined with the inertia of the pendulum, will increase the duration and amplitude of its oscillation, which will then no longer measure the velocity at the shock. Experiment has shown that, by means of an easily effected regulation, the time of stoppage of the system after the shock is, from a practical viewpoint, sufficient.

It will be remarked, perhaps, that in rounding a curve, if there is no equilibrium between the centrifugal force and the inclination of the track, the indications of the apparatus will be incorrect. This is obviated by the following arrangement, which is based upon the fact that the transverse motions produced by the variations in the centrifugal force and inclination combined are always much slower than the motions due to the shock. Consequently, a deadening that abolishes the effect of the first may allow that of the second to remain in force. In this improved arrangement, the frame that carries the pendulums forms, itself, with everything that it carries, a pendulum bob suspended from another frame, which is placed upon the platform of the car through the intermedium of a tripod provided with leveling screws. Two glycerine brakes deaden the slow oscillations of this latter frame, which spontaneously assumes a position of equilibrium corresponding to the action of the centrifugal force and inclination. The rapid oscillations of the two pendulums due to the shocks are registered without any trouble.

The only peculiarity of the registering apparatus is that its six receiving drums are arranged vertically in two rows and act upon the Richard pens through the intermedium of vertical shafts and horizontal levers. By modifying the relative lengths of the latter, the amplification of the registering apparatus is regulated according to the amplitude of the motions to be observed.

The registering apparatus weighs 62 pounds, the ballistic explorer 14, and the linear explorer 9¼.

This new arrangement is applicable to comparative study of tracks, to a comparison of the transverse stability of two cars, and to a comparison of two locomotive trucks, etc.



THE SABOURET APPARATUS FOR REGISTERING THE VIBRATIONS OF CAR-TRUCKS.

MUSICAL INSTRUMENTS: THEIR CONSTRUCTION AND CAPABILITIES.—II.*

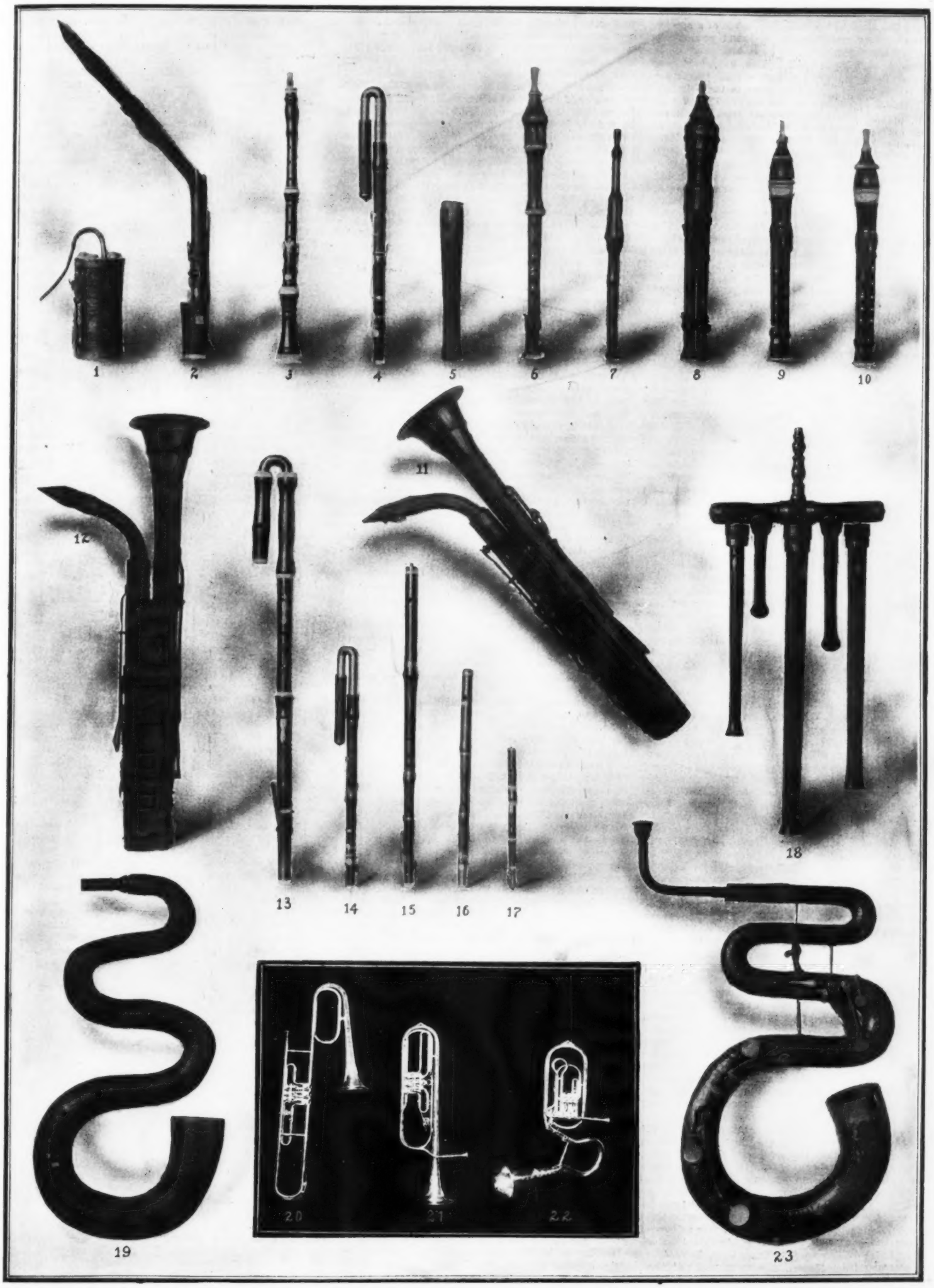
By A. J. HIPKINS.

I WILL now invite your attention to the wind instruments, which, in Handel's time, were chiefly used to double in unison the parts of stringed instruments. Their modern independent use dates from Haydn; it was extended and perfected by Mozart, Beethoven, and Weber; and the extraordinary changes and improvements which have been effected during the present century have given wind instruments an importance that is hardly exceeded by that of the stringed, in the formation of the modern orchestra. The military band, as it now exists, is a creation of the present century.

The so-called wood wind instruments are the flute, oboe, bassoon, and clarinet. It is as well to say at once that their particular qualities of tone do not absolutely depend upon the materials of which they are made. The form is the most important factor in determining the distinction of tone quality, so long as

* The illustrations of these articles depict instruments in the admirable collection of Mrs. Crosby Brown in the Metropolitan Museum of Art, New York city.

the sides of the tube are equally elastic, as has been submitted to proof by instruments made of various materials, including paper. I consider this has been sufficiently demonstrated by the independent experiments of Mr. Blaikley, of London, and Mr. Victor Mahillon, of Brussels. But we must still allow Mr. Richard Shepherd Rockstro's plea, clearly set forth in a recently published treatise on the flute, that the nature and the substance of the tube, by reciprocity of vibration, exercise some influence, although not so great as might have been expected, on the quality of the tone. But I consider this influence is already ac-



1. Wurst fagott with five finger holes and three flat brass keys on knobs. 2. Basset horn with twenty brass keys, the finger holes being covered by patent mechanism (19th century). 3. Oboe, made in France by Camus, 18th century. 4. Transverse flute, the head bent back in order to bring the finger holes within easy reach. 5 and 6. Double flutes. 7. Flageolet, French, 19th century. 8. Double flute. 9 and 10. Flutes à bec, in which the plug is covered by a hollow cup containing a sponge to absorb the moisture of the breath, at the top of which cup is a small ivory beak or mouthpiece. This cup acts as a porte vente or air-chamber. 11. Clarinet of Italian make, early 19th century. 12. Clarinet of French make. 13, 14, 15, 16, 17. Family of transverse flutes with keys. 18. Flute polyphonique, a combination of five flutes douces inserted in a hollow cross piece of wood to which is attached a central mouthpiece. The first, third and fifth flutes are parallel, the second and fourth placed at an angle. Made in Italy, 17th century. Attributed to Manfred Septalis. 19. Serpent. 20, 21, 22. Trombones with piston-valves. 23. Serpent made in England 1820. The instrument has fourteen keys supplying the chromatic scale. The serpent is an improvement on the old brass *Tin Ken* and is the invention of Edmé Guillaume, a canon of Auxerre, 1590.

WIND INSTRUMENTS.

knowledged in my reference to equality of elasticity in the sides of the tube.

The flute is an instrument of *embouchure*—that is to say, one in which a stream of air is driven from the player's lips against an edge of the blowhole to produce the sound. The oboe and bassoon have double reeds, and the clarinet a single reed, made of a species of cane, as intermediate agents of sound production. There are other flutes than that of *embouchure*—those with flageolet or whistle heads, which, having become obsolete, shall be reserved for later notice. There are no real tenor or bass flutes now, those in use being restricted to the upper part of the scale. The present flute dates from 1832, when Theobald Boehm, a Bavarian flute player, produced the instrument which is known by his name. He entirely remodeled the flute, being impelled to do so by suggestions from the performance of the English flautist, Charles Nicholson, who had increased the diameter of the lateral holes, and by some improvements that had been attempted in the flute by a Capt. Gordon, of Charles the Tenth's Swiss Guard. Boehm has been sufficiently vindicated from having unfairly appropriated Gordon's ideas. The Boehm flute, since 1846, is a cylindrical tube for about three-fourths of its length from the lower end, after which it is continued in a curved conical prolongation to the cork stopper. The finger holes are disposed in a geometrical division, and the mechanism and position of the keys are entirely different from what had been before. The full compass of the Boehm flute is chromatic, from middle C to C, two octaves above the treble clef C, a range of three octaves, which is common to all concert flutes, and is not peculiar to the Boehm model. Of course this compass is partly produced by altering the pressure of blowing. Columns of air inclosed in pipes vibrate like strings in sections, but, unlike strings, the vibrations progress in the direction of length, not across the direction of length. In the flute, all notes below D, in the treble clef, are produced by the normal pressure of wind; by an increasing pressure of over-blowing the harmonics, D in the treble clef, and A and B above it, are successively attained. The fingerholes and keys, by shortening the tube, fill up the required intervals of the scale. There are higher harmonics still, but flautists generally prefer to do without them when they can get the note required by a lower harmonic. In Boehm's flute, his ingenious mechanism allows the production of the eleven chromatic semitones intermediate between the fundamental note of the flute and its first harmonic, by holes so disposed that, in opening them successively, they shorten the column of air in exact proportion. It is, therefore, ideally, an equal-temperature instrument and not a D major one, as the conical flute was considered to be. Perhaps the most important thing Boehm did for the flute was to enunciate the principle that, to insure purity of tone and correct intonation, the holes must be put in their correct theoretical positions; and at least the hole below the one giving the sound must be open, to insure perfect venting. Boehm's flute, however, has not remained as he left it. Improvements, applied by Clinton, Pratten, and Carte, have introduced certain modifications in the fingering, while retaining the best features of Boehm's system. But it seems to me that the reedy quality obtained from the adoption of the cylindrical bore which now prevails does away with the sweet and characteristic tone quality of the old conical German flute, and gives us in its place one that is not sufficiently distinct from that of the clarinet.

The flute is the most facile of all orchestral wind instruments; and the device of double tonguing, the quick repetition of notes by taking a staccato T-stop in blowing, is well known. The flute generally goes with the violins in the orchestra, or sustains long notes with the other wood wind instruments, or is used in those conversational passages with other instruments that lend such a charm to orchestral music. The lower notes are not powerful. There is a flute which transposes a minor third higher than the ordinary flute; but it is not much used in the orchestra, although used in the army, as is also a flute one semitone higher than the concert flute. The piccolo, or octave flute, is more employed in the orchestra, and may double the melody in the highest octave, or accentuate brilliant points of effect in the score. It is very shrill and exciting in the overblown notes, and without great care may give a vulgar character to the music. The piccolo is exactly an octave higher than the flute, excepting the two lowest notes of which it is deficient. The old cylindrical ear-piercing fife is an obsolete instrument, being superseded by a small army flute, still, however, called a fife, used with the side drum in the drum and fife band.

The transverse or German flute, introduced into the orchestra by Lulli, came into general use in the time of Handel; before that the recorders, or flute douces, the flute à bec with beak or whistle head, were preferred. These instruments were used in a family, usually of eight members, viz., as many sizes from treble to bass; or in three, treble, alto or tenor, and bass. A fine original set of those now rare instruments, eight in number, was shown in 1890 in the music gallery of the Royal Military Exhibition, at Chelsea; a loan collection admirably arranged by Capt. C. R. Day. They were obtained from Hesse Darmstadt, and had their outer case to preserve them exactly like the recorder case represented in the painting by Holbein of the ambassadors, or rather, the scholars, recently acquired for the National Gallery. The flageolet was the latest form of the treble, beak, or whistle head flute. The whistle head is furnished with a cavity containing air, which, shaped by a narrow groove, strikes against the sharp edge and excites vibration in the conical pipe, on the same principle that an organ pipe is made to sound, or of the action of the player's mouth and lips upon the blowhole of the flute.

The oboe takes the next place in the wood wind band. The principle of sound excitement, that of the double reed, originating in the flattening of the end of an oat or wheat straw, is of great antiquity, but it could only be applied by insertions in tubes of very narrow diameter, so that the column of air should not be wider than the tongue of straw or reed acting upon it. The little reed, bound round and contracted below the vibrating ends in this primitive form, permitted the adjustment of the lower open end in the tube, it might be another longer reed or pipe which inclosed the air column; and thus a conical pipe that gradually narrows to the diameter of the tongue reed must have been early discovered, and was the original type of the pastoral and beautiful oboe of the modern orchestra.

Like the flute, the oboe has only the soprano register, extending from B flat or natural below middle C to F above the treble clef, two octaves and a fifth, which a little exceeds the flute downward. The foundation of the scale is D major, the same as the flute was before Boehm altered it. Triebert, a skillful Parisian maker, tried to adapt Boehm's reform of the flute to the oboe, but so far as the geometrical division of the scale was concerned, he failed, because it altered the characteristic tone quality of the instrument, so desirable for the balance of orchestral coloration. But the fingering has been modified with considerable success, although it is true by a much greater complication of means than the more simple contrivances that preceded it, which are still preferred by the players. The oboe reed has been much altered since the earlier years of this century. It was formerly more like the reed of the shawm, an instrument from which the oboe has been derived; and that of the present bassoon. It is now made narrower, with much advantage in the refinement of the tone. As in the flute, the notes up to C sharp in the treble clef are produced by the normal blowing, and simply shortening the tube by opening the sound holes. Beyond that note, increased pressure, or overblowing, assisted by a harmonic "speaker" key, produces the first harmonic, that of the octave, and so on. The lowest notes are rough and the highest shrill; from A to D above the treble clef, the tone quality of the oboe is of a tender charm in melody. Although not loud, its tone is penetrating and prominent. Its staccato has an agreeable effect. The place of the oboe in the wood wind band between the flute and the clarinet, with the bassoon for a bass, is beyond the possibility of improvement by any change.

Like the flute, there was a complete family of oboes in the sixteenth and early in the seventeenth century; the little schalmey, the discant schalmey, from which the present oboe is derived; the alto, tenor, pommer, and bass pommers, and the double quint or contrabass pommer.

In all these old finger hole instruments the scale begins with the first hole, a note in the bagpipe with which the drones agree, and not the entire tube. From the bass and double quint pommers came ultimately the bassoon and contra-bassoon, and from the alto pommer, an obsolete instrument for which Bach wrote, called the oboe di caccia, or hunting oboe, an appellation unexplained, unless it had originally a horn-like tone, and was, as it has been suggested to me by Mr. Blaikley, used by those who could not make a real hunting horn sound. It was bent to a knee shape to facilitate performance. It was not exactly the cor Anglais or English horn, a modern instrument of the same pitch which is bent like it, and of similar compass, a fifth below the usual oboe. The tenoroon, with which the oboe di caccia has been compared, was a high bassoon really an octave and a fifth below. It has been sometimes overlooked that there are two octaves in pitch between the oboe and bassoon, which has led to some confusion in recognizing these instruments. There was an intermediate instrument a third lower than the oboe, used by Bach, called the oboe d'amore, which was probably used with the cornemuse or bagpipe, and another, a third higher than the oboe, called musette (not the small bagpipe of that name). The cor Anglais is in present use. It is a melancholy, even mournful instrument, its sole use in the orchestra being very suitable for situations on the stage, the effect of which it helps by depressing the mind to sadness. Those who have heard Wagner's "Tristan und Isolde" will remember, when the faithful Kurwenal sweeps the horizon, and sees no help coming on the sea for the dying Tristan, how pathetically the reed pipe of a careless peasant near, played in the orchestra on a cor Anglais, colors the painful situation.

The bassoon is the legitimate bass to the oboe and to the wood wind in general. It was evolved in the sixteenth century from the pommers and bombards—the tenors and basses of the shawm or oboe family. With the older instruments, the reeds were not taken hold of immediately by the lips, but were held in a kind of cup, called *pirouette*, which only allowed a very small part of the reed to project. In the oboe and bassoon the player has the full control of the reed with the lips, which is of great importance, both in expression and intonation. The bassoon economizes length, by being turned back upon itself, and, from its appearance, obtains in Italy and Germany the satirical appellation of "fagotto" or "fagott." It is made of wood, and has not, owing to many difficulties as yet unsurmounted, undergone those changes of construction that have partly transformed other wood wind instruments. From this reason—and perhaps the necessity of a bassoon player becoming intimately familiar with his instrument—bassoons by some of the older makers—notably, Savory—are still sought after, in preference to more modern ones. The instrument, although with extraordinary advantages in tone, character, and adaptability, that render it valuable to the composer, is yet complicated and capricious for the performer; but its very imperfections remove it from the mechanical tendencies of the age, often damaging to art; and, as the player has to rely very much upon his ear for correct intonation, he gets, in reality, near to the manipulation of the stringed instruments. The bassoons play readily with the violoncellos, their united tone being often advantageous for effect. When not so used, it falls back into its natural relationship with the wood wind division of the orchestra. The compass of the bassoon is from B flat, an octave below that in the bass clef, to B flat in the treble clef, a range of three octaves, produced by normal pressure, as far as the bass clef F. The F below the bass clef is the true lowest note, the other seven semitones descending to the B flat being obtained by holes and keys in the long joint and bell. These extra notes are not overblown. The fundamental notes are extended as in the oboes and flutes by overflowing to another octave, and afterward to the twelfth. In modern instruments yet higher notes, by the contrivance of small harmonic holes and cross fingerings, can be secured. Long notes, scales, arpeggios, are all practicable on this serviceable instrument, and in full harmony with clarinets, or oboes and horns, it forms part of a rich and beautiful combination. There is a very telling quality in the upper notes of the bassoon of which composers have made use. Structurally, a bassoon consists of several pieces, the wing, butt, long joints, and bell, and when fitted together, they form a hollow cone of about eight feet long, the air column tapering in diameter from three-sixteenths of an inch at the reed to one and three-quarter inches at the bell end.

The bending back at the butt joint is pierced in one piece of wood, and the prolongation of the double tube is usually stopped by a flattened oval cork, but in some modern bassoons this is replaced by a properly curved tube. The height is thus reduced to a little over four feet, and the holes, assisted by the artifice of piercing them obliquely, are brought within reach of the fingers. The crook, in the end of which the reed is inserted, is about twelve inches long, and is adjusted to the shorter branch.

The contra-bassoon is an octave lower than the bassoon, which implies that it should go down to the double B flat, two octaves below that in the bass clef, but it is customary to do without the lowest as well as the highest notes of this instrument. It is rarely used, but should not be dispensed with. Messrs. Mahillon, of Brussels, produce a reed contra-bass of metal, intended to replace the contra-bassoon of wood, but probably more with the view of completing the military band than for orchestral use. It is a conical brass tube of large proportions, with seventeen lateral holes of wide diameter and in geometrical relation, so that for each sound one key only is required. The compass of this contra-bass lies between D in the double bass octave and the lower F of the treble clef.

The sarrusophones of French invention are a complete family, made in brass and with conical tubes pierced according to geometric relation, so that the sarrusophone is more equal than the oboe it copies and is intended, at least for military music, to replace. Being on a larger scale, the sarrusophones are louder than the corresponding instruments of the oboe family. There are six sarrusophones, from the sopranino in E flat to the contra-bass in B flat; and to replace the contra-bassoon in the orchestra there is a lower contra-bass sarrusophone made in C, the compass of which is from the double bass octave B flat to the higher G in the bass clef.

Before leaving the double reed wind instruments, a few words should be said of a family of instruments in the sixteenth century as important as the schalmeys, pommers, and bombards, but long since extinct. This was the cromorne, a wooden instrument with cylindrical column of air; the name is considered to remain in the cremona stop of the organ. The lower end is turned up like a shepherd's crook reversed, from whence the French name "tournebout." Cromorne is the German "krummhorn"; there is no English equivalent known.

The tone, as in all the reed instruments of the period, was strong and often bleating. The double reed was inclosed in a *pirouette*, or cup, and the keys of the tenor or bass, just the same as with similar flutes and bombards, were hidden by a barrel-shaped cover, pierced with small openings, apparently intended to modify the too searching tone as well as to protect the touch pieces which moved the keys. The compass was limited to fundamental notes, and from the cylindrical tube and reed was an octave lower in pitch than the length would show. In all these instruments provision was made in the holes and keys for transposition of the hands according to the player's habit of placing the right or left hand above the other. The unused hole was stopped with wax. There is a fine and complete set of four cromornes in the museum of the Conservatoire at Brussels.

We must also place among double-reed instruments the various bagpipes, cornemuses, and musettes, which are shawm or oboe instruments with reservoirs of air, and furnished with drones inclosing single reeds. I shall have more to say about the drone in the third lecture. In restricting our attention to the Highland bagpipe, with which we are more or less familiar, it is surprising to find the peculiar scale of

the chaunter, or finger pipe, in an old Arabic scale, still prevailing in Syria and Egypt. Dr. A. J. Ellis' lecture on "The Musical Scales of Various Nations," read before the Society of Arts, and printed in the Journal of the Society, March 27, 1885, No. 1688, vol. xxxiii., and to an appendix, October 30, 1885, in the same volume, should be consulted by any one who wishes to know more about this curious similarity.

We have now arrived at the clarinet. Although embodying a very ancient principle—the "squeaker" reed which our little children still make, and continued in the Egyptian arghool—the clarinet is the most recent member of the wood wind band. The reed initiating the tone by the player's breath is a broad, single, striking or beating reed, so called because the vibrating tongue touches the edges of the body of the cutting or framing. A cylindrical pipe, as that of the clarinet, drops, approximately, an octave in pitch when the column of air it contains is set up in vibration by such a reed, because the reed virtually closes the pipe at the end where it is inserted, and like a stopped organ pipe sets up a node of maximum condensation or rarefaction at that end. This peculiarity interferes with the resonance of the even-numbered partials of the harmonic scale, and permits only the odd-numbered partials, 1, 3, 5, and so on, to sound. The first harmonic, as we find in the clarinet, is therefore the third partial, or twelfth of the fundamental note, and not the octave, as in the oboe and flute.

In the oboe the shifting of the nodes in a conical tube open at its base, and narrowing to its apex, permits the resonance of the complete series of the harmonic scale, 1, 2, 3, 4, 5, and upward. The flute has likewise the complete series, because through the blowhole it is a pipe open at both ends. But while stating the law which governs the pitch and harmonic scale of the clarinet, affirmed equally by observation and demonstration, we are left at present with only the former when regarding two very slender, almost cylindrical reed pipes, discovered in 1889 by Mr. Flinders Petrie while excavating at Fayoum the tomb of an Egyptian lady named Maket. Mr. Petrie dates these pipes about 1100 B. C., and they were the principal subject of Mr. Southgate's recent lectures upon the Egyptian scale.

The clarinet was invented about A. D. 1700, by Christopher Denner, of Nuremberg. By his invention, an older and smaller instrument, the chalumeau, of eleven notes, without producible harmonics, was, by an artifice of raising a key to give access to the air column at a certain point, endowed with a harmonic series of eleven notes a twelfth higher. The chalumeau being a cylindrical pipe, the upper partials could only be in an odd series, and when Denner made them speak, they were consequently not an octave, but a twelfth above the fundamental notes. Thus, an instrument which ranged, with the help of eight finger holes and two keys, from F in the bass clef to B flat in the treble had an addition given to it at once of a second register from C in the treble clef to E flat above it. The scale of the original instrument is still called chalumeau by the clarinet player; about the middle of the last century it was extended down to E. The second register of notes, which by this lengthening of pipe started from B natural, received the name of clarinet, or clarionet, from the clarino or clarion, the high solo trumpet of the time it was expected that this bright harmonic series would replace.

This name of clarinet, or clarionet, became accepted for the entire instrument, including the chalumeau register. It is the communication between the external air and the upper part of the air column in the instrument which, initiating a ventral segment or loop of vibration, forces the air column to divide for the next possible partial, the twelfth, that Denner has the merit of having made practicable. At the same time the manipulation of it presents a difficulty in learning the instrument. It is in the nature of things that there should be a difference of tone quality between the lower and upper registers thus obtained; and that the highest fundamental notes, G sharp, A and B flat, should be colorless compared with the first notes of the overblown series. This is a difficulty the player has to contend with, as well as the complexity of fingering, due to there being no less than eighteen sound holes. Much has been done to graft Boehm's system of fingering upon the clarinet, but the thirteen key system, invented early in this century by Iwan Muller, is still most employed. The increased complication of mechanism is against a change, and there is even a stronger reason, which I cannot do better than translate, in the appropriate words of M. Lavoix fils, the author of a well-known and admirable work upon instrumentation:

"Many things have still to be done, but inventors must not lose the point in view, that no tone quality is more necessary to the composer than that of the clarinet in its full extent; that it is very necessary especially to avoid melting together the two registers of chalumeau and clarinet, so distinct from each other. If absolute justness for these instruments is to be acquired at the price of those inestimable qualities, it would be better a hundred times to leave it to virtuosi, thanks to their ability, to palliate the defects of their instrument, rather than sacrifice one of the most beautiful and intensely colored voices of our orchestra."

There are several clarinets of various pitches, and formerly more than are used now, owing to the difficulty of playing except in handy keys. In the modern orchestra the A and B flat clarinets are the most used; in the military band, B flat and E flat. The C clarinet is not much used now. All differ in tone and quality; the A one is softer than the B flat; the C is shrill. The B flat is the virtuoso instrument. In military bands the clarinet takes the place which would be that of the violin in the orchestra, but the tone of it is always characteristically different. Although introduced in the time of Handel and Bach those composers made no use of it. With Mozart it first became a leading orchestral instrument.

The Basset horn, which has become the sensuously beautiful alto clarinet in E flat, is related to the clarinet in the same way that the cor Anglais is to the oboe. Basset is equivalent to Baryton (there is a Basset flute figured in Prætorius), and this instrument appears to have been invented by one Horn, living at Passau, in Bavaria, about 1770. His name given to the instrument has been mistranslated into Italian as Corno di Bassetto. There is a bass clarinet employed with effect by Meyerbeer in the "Huguenots," but the characteristic clarinet tone is less noticeable; it is, however, largely used in military bands. The Basset horn had the deep compass of the bass clarinet which separates it from the present alto clarinet, although it was more like the alto in caliber. The alto clarinet is also used in military bands; and probably what the Basset horn would have been written for is divided between the present bass and alto clarinets.

Preceding the invention of the sarrusophone, by which a perfected oboe was contrived in a brass instrument, a modified brass instrument, the saxophone, bearing a similar relation to the clarinet, was invented in 1846 by Sax, whose name will occur again and again in connection with important inventions in military band instruments. The saxophone is played like the clarinet with the intervention of a beating reed, but is not cylindrical; it has a conical tube like the oboe. The different shape of the column of air changes the first available harmonic obtained by overblowing to the octave instead of the twelfth; and also in consequence of the greater strength of the even harmonics, distinctly changing the tone quality. The sarrusophone may fairly be regarded as an oboe or bassoon; but the saxophone is not so closely related to the clarinet. There are four sizes of saxophone now made between high soprano and bass. Starting from the fourth fundamental note, each key can be employed in the next higher octave, by the help of other two keys, which, being opened successively, set up a vibrating loop. The saxophones, although difficult to play, fill an important place in the military music of France and Belgium, and have been employed with advantage in the French orchestra. The fingering of all saxophones is that attributed to Boehm.

The cup-shaped mouthpiece must now take the place of the reed in our attention. Here the lips fit against a hollow cup-shaped reservoir, and, acting as vibrating membranes, may be compared with the vocal chords of the larynx. They have been described as acting as true reeds. Each instrument in which such a mouthpiece is employed requires a slightly different form of it. The French horn is the most important brass instrument in modern music. It consists of a body of conical shape about seven feet long, without the crooks, ending in a large bell, which spreads out to a diameter of fifteen inches. The crooks are fitted between the body and the mouthpiece; they are a series of smaller interchangeable tubings, which extend in length as they descend in pitch, and set the instrument in different keys. The mouthpiece is a funnel-shaped tube of metal, by preference silver; and, in the horn, is exceptionally not cup-shaped, but the reverse: it tapers, as a cone, from three-quarters of an inch diameter to about a minimum of three-sixteenths of an inch, and is a quarter of an inch where the smaller end of the mouthpiece is inserted in the upper opening of the crook. The first horn has a mouthpiece of rather less diameter than the second. The peculiar mouthpiece and narrow tubing have very much to do with the soft voice-like tone quality of the horn. For convenience of holding, the tubing is bent in a spiral form. There is a tuning slide attached to the body, and, of late years, valves have been added to the horn, similar to those applied to the cornet and other wind instruments. They have, to a considerable extent, superseded hand stopping, by which expedient the intonation could be altered a semitone or whole tone, by depression of the natural notes of the instrument. In brass, or other instruments, the natural harmonics depend on the pressure of blowing; and the brass differs entirely from the wood wind, in this respect, that it is rare, or with poor effect, the lowest or fundamental note can be made to sound. Stopping the horn is done by extending the open hand some way up the bore; there is half stopping and whole stopping, according to the interval, the half tone or whole tone required. As may be imagined, the stopped notes are weak and dull compared with the open. On the other hand, the tubing introduced for valves not being quite conformable in curve with the instrument, and hampered with indispensable joints, unless in the best form of modern valve, affects the smoothness of tone. No doubt there has been of late years a great improvement in the manufacture of valves. Many horns are still made with crooks covering an octave from B flat to B flat, 8 feet 6 inches to 17 feet; but most players now use only the F crook, and trust to the valves, rather than to change the crooks, so that we lose the fullness of sound of those below F. The natural horn was originally in D, but was not always restricted to that key; there have been horns for F, G, high A, and B flat. This may, however, be said for the valve horn, that it does not limit or restrict composers in writing for the open or natural notes, which are always more beautiful in effect.

Valves were invented and first introduced in Prussia about A. D. 1815. At first there were two, but there are now generally three. In this country and France they are worked by pistons, which, when pressed down, give access for the air into channels or supplementary tubings on one side of the main bore, thus lengthening it by a tone for the first valve, a semitone for the second, and a tone and a semitone for the third. When released by the finger, the piston returns by the action of a spring. In large bass and contralto instruments, a fourth piston is added, which lowers the pitch two tones and a semitone. By combining the use of three valves, lower notes are obtained—thus, for a major third, the second is depressed with the third; for a fourth, the first and third; and for the tritone, the first, second, and third. But the intonation becomes imperfect when valves are used together, because the lengths of additional tubing being calculated for the single depressions, when added to each other, they are too short for the deeper notes required. By an ingenious invention of compensating pistons, Mr. Blaikley, of Messrs. Boosey's, has practically rectified this error without extra moving parts or altered fingering. In the valve section, each altered note becomes a fundamental for another harmonic scale. In Germany a rotary valve, a kind of stop cock, is preferred to the piston. It is said to give greater freedom of execution, the closeness of the shake being its best point, but is more expensive and liable to derangement. The invention of M. Adolphe Sax, of a single ascending piston in place of a group of descending ones, by which the tube is shortened instead of lengthened, met, for a time, with influential support. It is suitable for both conical and cylindrical instruments, and has six valves, which are always used independently. However, practical difficulties have interfered with its success. With any valve system, however, a difficulty with the French horn is its great variation in length by crooks, inimical to the principle of the valve system, which relies upon an adjustment by aliquot parts. It will, however, be seen that the invention of valves has, by transforming and extending wind instruments, so as to become chromatic, given many advantages to the composer. Yet it must, at the same time, be conceded, in spite of the increasing favor shown for valve instruments, that the tone must issue more freely, and with more purity and beauty, from a simple tube than from tubes with joinings and other complications, that interfere with the regularity and smoothness of vibration, and, by mechanical facilities, tend to promote a dull uniformity of tone quality.

Owing to the changes of pitch by crooks, it is not easy to define the compass of the French horn. Between C in the bass clef and G above the treble will represent its serviceable notes. It is better that the first horn should not descend below middle C, or the second rise above the higher E of the treble clef. Four are generally used in modern scores. The place of the horn is with the wood wind band. From Handel, every composer has written for it, and what is known as the small orchestra of string and wood wind bands combined is completed by this beautiful instrument.

The most prominent instruments that add to the splendor of the full orchestra are trumpets and trombones. They are really members of one family, as the name trombone—big trumpet—implies, and blend well together. The trumpet is an instrument of court and state functions, and, as the soprano instrument, comes first. It is what is known as an eight-foot instrument in pitch, and gives the different harmonics from the third to the twelfth, and even to the sixteenth. It is made of brass, mixed metal, or silver, and is about five feet seven inches in real length, when intended for the key of F without a slide; but is twice turned back upon itself, the first and third lengths lying contiguous, and the second about two inches from them. The diameter is three-eighths of an inch along the cylindrical length; it then widens out for about fifteen inches, to form the bell.

When fitted with a slide for transposition—an invention for the trumpet in the last century—this double tubing, about five inches in length on each side, is connected with the second length. It is worked from the center with the second and third fingers of the right hand, and, when pulled back, returns to its original position by a spring. There are five crooks. The mouthpiece is hemispherical and convex, and the exact shape of it is of great importance. It has a rim with slightly rounded surface. The diameter of the mouthpiece varies according to the player and the pitch required. With the first crook, or rather shank, and mouthpiece, the length of the trumpet is increased to six feet, and the instrument is then in the key of F. The second shank transposes it to E, the third to E flat, and the fourth to D. The fifth, and largest—two feet one and a half inches long—extends the instrument to eight feet, and lowers the key to C. The slide is used for transposition by a semitone or a whole tone, thus making new fundamentals, and correcting certain notes of the natural harmonic scale, as the seventh, eleventh, and thirteenth, which do not agree with our musical scale. Mr. W. Wyatt has recently taken out a patent for a double-slide trumpet, which possesses a complete chromatic scale. In the required length of slide the ear has always to assist. It is clear that the very short shifts of a double slide demand great nicety of manipulation. It is, of course, different with the valve trumpet. The natural trumpets are not limited to one or two keys, but those in F, E, E flat, D, B flat, and even A have been employed; but, usually, the valve trumpets are in F, and the higher B flat, with a growing inclination, but an unfortunate one, to be restricted to the latter, it being easier for cornet players. The tone of the high B flat trumpet cannot, however, compare with the F one, and with it the lowest notes are lost. Of course, when there are two or three

trumpets, the high B flat one finds a place. However, the valve system applied to the trumpet is not regarded with satisfaction, as it makes the tone dull. For grand heroic effect, valve trumpets cannot replace the natural trumpets with slides, which are now only to be heard in this country.

The simple or field trumpet appears to exist now in one representative only, the E flat cavalry trumpet. Bach wrote for trumpets up to the twentieth harmonic—but for this the trumpet had to be divided into a principal, which ended at the tenth harmonic—and the clarino in two divisions, the first of which went from the eighth harmonic up to as high as the player could reach, and the second clarino, from the sixth to the twelfth. The use of the clarinet by composers about the middle of the last century seems to have abolished these very high trumpets. So completely had they gone, by the time of Mozart, that he had to change Handel's trumpet parts, to accommodate them to performers of his own time, and transfer the high notes to the oboes and clarinets.

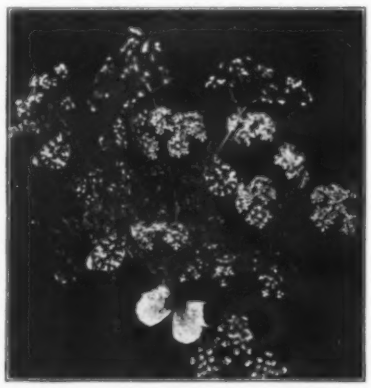
Having alluded to the cornet à piston, it may be introduced here, particularly as from being between a trumpet and a bugle, and of four-foot tone, it is often made to do duty for the more noble trumpet. But the distinctive feature of this, as of nearly all brass instruments since the invention of valves, tends to a compromise instrument, which owes its origin to the bugle. The cornet à piston is now not very different from the valve bugle in B flat on the one hand, and from the small valve trumpet in the same key on the other. It is a hybrid between this high pitch trumpet and the bugle, but compared with the latter it has a much smaller bell. By the use of valves and pistons, with which it was the first to be endowed, the cornet can easily execute passages of consecutive notes that in the natural trumpet can only be got an octave higher. It is a facile instrument, and double tonguing, which is also possible with the horn and trumpet, is one of its popular means for display. It has a harmonic compass from middle C to C above the treble clef, and can go higher, but with difficulty. A few lower notes, however, are easily taken with the valves.

We now come to the trombones, grand, sonorous tubes, which, existing in three or four sizes since the sixteenth century, are among the most potent additions on occasion to the full orchestra. Their treble can be regarded as the English slide trumpet, but it is not exactly so. There appears to have been as late as Bach a soprano trombone, and it is figured by Virdung, A. D. 1511, as no larger than the field trumpet. The trumpet is not on so large a caliber, and in the seventeenth century had its own family of two clarinos and three tubas. The old English name of the trombone is sackbut. The old wooden cornet, or German zinke, an obsolete, cupped mouthpiece instrument, the real bass of which, according to family, is the now obsolete serpent, was used in the sixteenth and seventeenth centuries as the treble instrument in combination with alto, tenor, and bass trombones. The leading features of the trumpet are also found, as already inferred, in the trombone; there is the cupped mouthpiece, the cylindrical tubing, and, finally, a gradual increase in diameter to the bell. The slide used for the trumpet appears for four centuries, and probably longer, in the well-known construction of the trombone. In this instrument it consists of two cylindrical tubes parallel with each other, upon which two other tubes communicating by a pipe at their lower ends curved in a half circle glide without loss of air. The mouthpiece is fitted to an upper end, and a bell to a lower end of the slide. When the slide is closed, the instrument is at its highest pitch, and as the column of air is lengthened by drawing the slide out, the pitch is lowered. By this contrivance a complete chromatic scale can be obtained, and as the determination of the notes it produces is by ear, we have in it the only wind instrument that can compare in accuracy with stringed instruments. The player holds a cross bar between the two lengths of the instrument, which enables him to lengthen or shorten the slide at pleasure, and in the bass trombone, as the stretch would be too great for the length of a man's arm, a jointed handle is attached to the cross bar. The player has seven positions, each a semitone apart for elongation, and each note has its own system of harmonics, but in practice he only occasionally goes beyond the fifth. The present trombones are the alto in E flat descending to A in the seventh position; the tenor in B flat descending to E; the bass in F descending to B, and a higher bass in G descending to C sharp. Wagner, who has made several important innovations in writing for bass brass instruments, requires an octave bass trombone in B flat; an octave lower than the tenor one, in the "Nibelungen." The fundamental tones of the trombone are called "pedal" notes. They are difficult to get and less valuable than harmonics because, in all wind instruments, notes produced by overblowing are richer than the fundamental notes in tone quality. Valve trombones do not, however, find favor, the defects of intonation being more prominent than in shorter instruments. But playing with wide bore tubas and their kindred is not advantageous to this noble instrument.

The serpent has been already mentioned as the bass of the obsolete zinken or wooden cornets, straight or curved, with cupped mouthpiece. It gained its serpentine form from the facility given thereby to the player to cover the six holes with his fingers. In course of time keys were added to it, and when changed into a bassoon shape its name changed to the Russian bass horn or basson Russe. A Parisian instrument maker, Halary, in 1817, made this a complete instrument, after the manner of the keyed bugle of Halliday, and producing it in brass called it the ophicleide, from two Greek words meaning serpent and keys—keyed serpent—although it was more like a keyed bass bugle. The wooden serpent has gone out of use in military bands within recollection, the ophicleide from orchestras only recently. It has been superseded by the development of the valved tubas. The euphonium and bombardon, the basses of the important family of saxhorns, now completely cover the ground of bass wind instrument music. The keyed bugle, invented by Joseph Halliday, bandmaster of the Cavan militia, in 1810, may be regarded as the prototype of all these instruments, excepting that the keys have been entirely replaced by the valve system, an almost contemporary invention by Stölzel and Blumel, in Prussia, in 1815. The valve instruments began to prevail as early as 1850. The sound tube of all bugles, saxhorns, and tubas is conical, with a much wider curve than the horn. The quality of tone produced is a general kind of tone, not possessing the individuality of any of the older instruments. All these valve instruments may be comprehended under the French name of saxhorn. There is a division between them of the higher instruments or bugles, which do not sound the fundamental note, and of the lower, or tubas, which sound it readily. Properly military band instruments, the second or bass division has been taken over to the orchestra; and Wagner has made great use of it in his great scores. The soprano cornets, bugles, or flugelhorns and saxhorns are in E flat; the corresponding alto instruments in B flat, which is also the pitch of the ordnary cornet. The tenor, baryton, and bass instruments follow in similar relation; the bass horns are, as I have said, called tubas; and that with four valves, the euphonium. The bombardon, or E flat tuba, has much richer lower notes.

For military purposes, this and the contrabass—the helicon—are circular. Finally, the contrabass tubas in B flat, and in C, for Wagner, have immense depth and potentiality of tone; all these instruments are capable of pianissimo.

There are many varieties now of these brass instruments, nearer particulars of which may be found in Gevaert, and other eminent musicians' works on instrumentation. One fact I will not pass by, which is



GROUP OF ORANGE-TIP BUTTERFLIES AND COW PARSLEY.

that, from the use of brass instruments (which rise in pitch so rapidly under increase of temperature, as Mr. Blaikley has shown, almost to the coefficient of the sharpening under heat in organ pipes) has come about that rise in pitch which, from 1816 to 1846—until repressed by the authority of the late Sir Michael Costa, and, more recently, by the action of the Royal Military College at Kneller Hall—is an extraordinary feature in musical history. All previous variations in pitch—and they have comprised as much as a fourth in the extremes—having been due either to transposition, owing to the requirements of the human voice, or to national or provincial measurements. The manufacture of brass instruments is a distinct craft, although some of the processes are similar to those used by silversmiths, coppersmiths, and braziers.

(To be continued.)

FLOWER MIMICS AND ALLURING RESEMBLANCE.*

By PERCY COLLINS.

NOT the least curious insects which gain protection from their enemies by means of a likeness to surrounding objects are those which may be described as flower mimics. Of these, some remarkable instances have already been described, nor is it unlikely that others, equally striking, remain to be discovered. Among butterflies, one may often trace a likeness between the resting insect and the buds or blooms among which it has settled. This flower resemblance is seen in the case of our common "white" butterflies, which, when settled among such blossoms as those of the pea tribe, have an undeniable general likeness to the unopened flowers. Again, a contributor to the Speaker recently pointed out the resemblance of the resting "wood white" butterfly (*Leucophasia sinapis*) to the flower buds of the corn wheat—a plant invariably abundant in the woods frequented by this dainty insect. The present writer is able to substantiate this observation, being familiar with one of the few remaining districts wherein the "wood white" is still fairly common.

* Knowledge.

A more specialized case of floral simulation is seen in the "orange-tip" butterfly (*Euchloë cardamines*), an insect familiar to all lovers of the outdoor world. The upper surface of this butterfly's wings are white marked with black, with (in the male only) two large orange areas in the fore wings. The coloring of the underside, which is identical in both sexes, seems designed in imitation of a small truss of the tiny white florets of some umbelliferous plant, such as the hedge parsley. Such pale or white flower masses are among the commonest blossoms of the hedgerow in the springtime, when the "orange-tip" butterflies are on the wing. It is, of course, extremely doubtful whether the butterflies have any knowledge of their protective coloring;

A SPECIES OF FLATA FROM PERAK.

Somewhat enlarged.

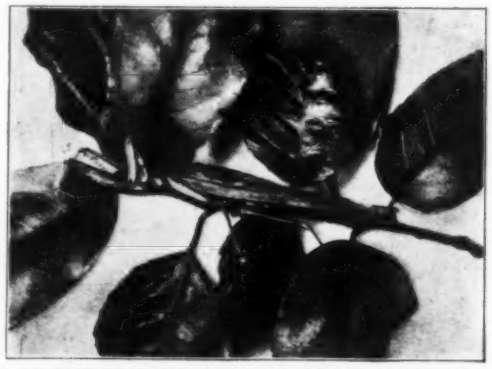
nor is there any ground for supposing that the insects select the neighborhood of umbelliferous blooms as resting places. At the same time, it seems quite admissible to suppose that the color likeness of *E. cardamines* to florescence common in spots frequented by the insect is likely to stand it in good stead as a protective disguise. The underside of the hind wings, between which the fore wings are folded when the insect is at rest, are mottled white and green—the white patches resembling tiny florets, while the green represents the background of vegetation against which they are supposed to be seen. Those who have not observed the "orange tip" butterfly in nature may

INDIVIDUALS OF A SPECIES OF FLATA GROUPED UPON A PLANT STEM.

Note flower-like appearance.

judge of the closeness of the protective resemblance by a glance at the accompanying photograph.

Several of our common "blue" butterflies have wings mottled and spotted on the under surfaces in a manner which suggests the plantain heads and grass flowers among which these insects are accustomed to rest. And as these butterflies are accustomed to go to roost long before twilight has settled in, it is quite likely that their shape and coloring protect them from the attacks of birds.



A GREEN MANTID, FROM CEYLON, LYING IN WAIT AMONG FOLIAGE.

Perhaps the most curious case of protective flower resemblance is that vouched for by Prof. Gregory, and described in his work, "The Great Rift Valley." The insect in question is a species of *Flata*, which is a genus allied to the scale-insects, and to the *Aphidæ*. The species described by Prof. Gregory is indigenous to British East Africa, and is dimorphic—a certain number of individuals of each sex being bright pink in

color, while others are bright green. These insects resemble the green fly, or *Aphidæ*, in habits, sitting motionless on plant stems for long periods and feeding upon the sap. The manner in which the individuals of the present species are said to group themselves is very remarkable. The pink ones sit upon the lower

BROWN MANTID, FROM USAMBAVA, AT REST ON BARK.

part of the stem, while the green ones have their place above, toward the extremity. Further, the developing larvæ, which secrete long filaments of a waxy substance, and are quaint, fluffy little objects, sit beneath the pink individuals at the lowest part of the stem. Thus, the exact appearance of a spiked inflorescence is simulated. The fluffy larvæ have a distinct likeness to seed pods. The pink individuals might be mistaken for drooping flowers, while the green ones, higher up the stem, look like so many undeveloped buds. Prof. Poulton, however, has remarked that the grouping of green and pink insects in Prof. Gregory's observation was probably accidental.

So far, we have examined only instances of protective resemblance—instances, that is to say, in which the colors, or the colors and form, of an insect are seen to be of value to it as a means of escaping detection. We have now to consider cases in which the appearances of insects, while possibly screening them from the attacks of their enemies, have the additional advantage of enabling them to approach unobserved the creatures upon which they themselves prey. Such instances of resemblance may be termed aggressive.

The curious "praying insects," or *Mantidæ*, afford many striking examples of aggressive resemblance. The whole of this large family is insectivorous in habit, and the majority of the species are either green or brown in color. So that when sitting motionless among foliage, or upon the bark of trees, they are not only inconspicuous to such enemies as birds and lizards, but are also hidden from the small insects which form, in the main, their food.

The *Mantidæ* are almost all sluggish in their move-

ANOTHER VIEW OF SAME INSECT.

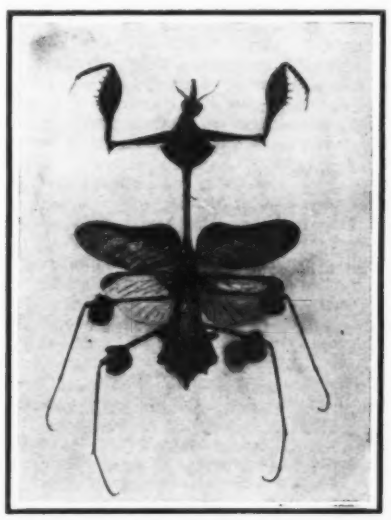
ments, seeming to be aware that the needs of their life will be best served by tranquillity, rather than by effort. They sit motionless in the sunshine—brown species upon bark, green species among foliage—and wait. At most their activity consists in a stealthy stalking among the leaves until they come within striking distance of their victims. The first pair of legs in *Mantidæ* is useless for walking, but is wonderfully modified to serve as "clappers" for seizing prey. In the use of these limbs the insects are very rapid and dexterous, not only capturing insects which have settled upon a leaf, but even grasping them when actually on the wing. The rows of sharp spines with which the modified femur and tibia are armed make it impossible for the prey to escape when once the mantis has seized it.

It has been said that most of the *Mantidæ* are either green or brown in color. A few brightly-colored species, however, have been described. The colors may be restricted to a certain area or may suffuse the whole surface of the insect. And when these insects assume their characteristic attitudes among vegetation, these colors often give them a curiously flower-like aspect. Now, it is well known that highly specialized flowers rely mainly upon the aid of insects to secure cross-fertilization, and that honey is secreted as a bait to attract the winged visitors. It has, moreover, been demonstrated that the colors and markings of flowers attract honey-gathering insects. Bearing these facts in mind, it is not difficult to realize that a quaintly shaped and brightly colored mantis, hanging motionless among green foliage, might, at times, be mistaken by other insects for a flower. That such mistakes actually occur has been vouched for by several observers.

Dr. Wallace mentions an insect (*Hymenopus bicornis*), discovered by Mr. Wood Mason, which attracts insects to their destruction by its flower-like shape

RAPTORIAL LIMBS OF A TYPICAL MANTID.

and pink or white color. Parts of the insect's legs are so flattened as to simulate the petals of the supposed flower. In this instance, the whole of the mantis looks like an orchid, but in the case of *Idolium diabolicum*, from Mozambique, a drawing of which is exhibited in the Natural History Museum at South Kensington, only the under surface of the thorax and fore-limbs



GONGYLUS GONGYLOIDES, FROM SOUTHERN INDIA.

have a flower-like color and form. The body, wings, and hind legs are greenish or brown, in harmony with the foliage by which they are partially hidden when the insect is lying in wait for a meal.

Perhaps the most authentic instance of alluring resemblance is that described on the authority of Dr. J. Anderson. The mantis is *Gongylus gongyloides* from Southern India—a species which has been known to naturalists for upward of three centuries, but of whose strange habits nothing was discovered until comparatively recent years. Living examples of *Gongylus* have been thus described:* "On looking at the insects from above they did not exhibit any very striking features beyond the leaf-like expansions of the prothorax and the foliaceous appendages of the limbs, both of which, like the upper surface of the insect, are colored green, but on turning to the under surface the aspect is entirely different. The leaf-like expansion of the prothorax, instead of being green, is a clear, pale lavender-

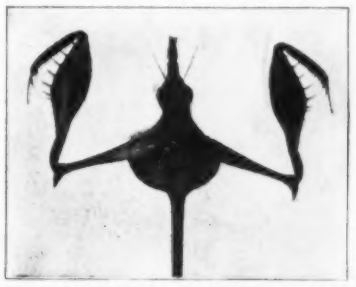
PROTHORAX, RAPTORIAL LIMBS AND HEAD OF G. GONGYLOIDES IN FLOWER-MIMICKING POSE.

The insect is hanging head downward.

violet, with a faint pink bloom along the edges of the leaf, so that this portion of the insect has the exact

* Pro. Asiat. Soc. Bengal, 1877, p. 193.

appearance of the corolla of a plant, a floral simulation which is perfected by the presence of a dark, blackish-brown dot in the center, over the prothorax, and which mimics the opening to the tube of a corolla. A favorite position of the insect is to hang head downward among a mass of green foliage, and, when it does so, it generally remains almost motionless, but, at intervals, evinces a swaying movement as of a flower touched by a gentle breeze; and while in this attitude, with its fore-limbs banded violet and black, and drawn up in front of the center of the corolla, the simulation



G. GONGYLOIDES. RAPTORIAL LIMBS EXPANDED TO SEIZE PREY.

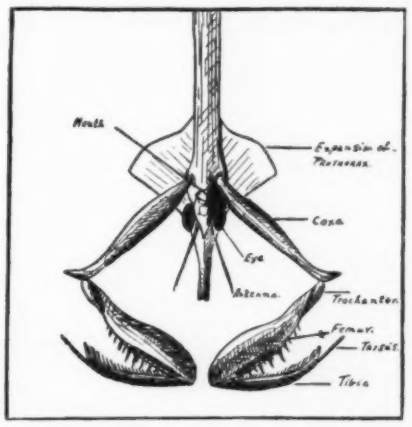
of a papilionaceous flower is complete. The object of the bright coloring of the under surface of the prothoracic expansion is evident, its purpose being to act as a decoy to insects, which, mistaking it for a corolla, fly directly into the expectant, saber-like, raptorial arms of the simulator."

A more perfect combination of protective and alluring resemblance than the above could hardly be conceived. The green coloring of the body and legs of the *Gongylus* harmonizes with the foliage among which it rests, and affords an effective hiding from the sharp eyes of insectivorous birds. The unusual shape and brightly-colored under side of its prothorax and fore-limbs constitute a lure, by means of which the mantis attracts to itself the smaller insects upon which it feeds.

BIOLOGICAL NOTES ON THE MERGING OF NOTABLE RACIAL CHARACTERISTICS.

By CARL F. GISSLER.

IT is said that the English race is the most heterogeneous, the most complex in Europe. It must also be admitted, that the American race is more complex than the English, and therefore superior in scale. Most Europeans do not at all comprehend the uniformly great virility of the American race. Biologically viewed, the great function of the American nation is the gradual absorption of all European characters, including their various languages, manners, etc., into one great distinctive race, the American. The people of the United States, whether from Maine, New York, Alabama, Indian Territory, California, or any other section of this immense territory, although possessing



G. GONGYLOIDES. KEY DIAGRAM OF PROTHORAX, RAPTORIAL LIMBS AND HEAD; AND VENTRAL SURFACE.

Insect hanging head downward.

characteristics of thought, speech, voice, and manner somewhat peculiar to their own section, all have in common a distinctively American individuality; and in all cardinal motives, necessary to maintain and perpetuate the foremost principles of progress, for which a nation as a whole can stand at this time in the world's progress, the people are practically united. It is not so with Europe. In Austria, for instance, where there are several subdivisions and languages, there is almost constant strife between them. In Great Britain, the most heterogeneous element in Europe, the Celts are opponents everywhere.

Almost none of the various characteristics, such as gait, carriage of body, physiognomy, etc., of these Europeans is found in the first generation after immigration to this country. If at all present, for instance, in Pennsylvania, any such characteristics are weakened, becoming fainter in the second generation. If present, they are most conspicuous during adolescence, and more so in the male than in the female. Later on, in adult life, these characters become more or less evan-

escent. Generally, and very broadly speaking, there seems to exist in the physiognomy of the American, as accentuated in the male, a decided difference from that of the European. The features of the male American appear to be more rounded off, and the same is often true also of the female during adolescence. A mutation or change takes place, a sort of leveling out, as it were, of the European angularities of body and physiognomy. Such eccentricities as pertain to the length of the neck, the height of the forehead, the various prognathities, curve of back, length of the legs and arms, oddities in carriage, gait, motion in general, and many other general characteristics of the English female are thus leveled out.

These truths led to the exalted expressions of H. D. Howell, and numerous other critics, which amount in a certain sense to an apotheosis of the American female, and culminated in what the Europeans call, and is here termed in German "frauen cultus." In making a comparison, the British was selected; of the Canadians but a few notes were taken, such as pertain to those of British descent only. In Canada we notice higher foreheads and stronger transverse frontal wrinkles than those found even in the New England States.

As a matter of course, there is no morphological rounding off of the structural, bony skeleton of the skull. The hypothetical rounding off could be given a new name, but as J. Tyndall said, we should "avoid confusion by fixing the mind upon things rather than upon names," it was omitted.

In order to generalize the various American characteristics, the writer has numbered them, not however in accordance with their respective merits:

a. Features rounded off and in other respects modified.

b. The transverse frontal wrinkles of Europeans are generally wanting in the adolescent American female.

c. The tone color of the American voice.

d. The glistening sclerotic of the eyes of the American female.

e. The less violent emotions in either sex.

f. The quicker perception of thought.

g. The American gestures.

h. The American round handwriting.

a. Features rounded off and modified. The marginals, the periphery of the entire front of the American physiognomy, are peculiarly rounded off. Observations of the scalp over the frontal eminences, the under and lateral parts of the chin, the upper part of the lower nose, the edges of the wings, and the expansions of the nostrils and septum, the entire *Platysma myoides*, or covering of the neck, with its adipose tissue, show that the periphery and angulation of all these anatomical parts of the European physiognomy have become more or less evolutionized, rounded off, as it were, in the American. From Mr. O. T. Mason, curator of the American National Museum at Washington, I learned but recently that Prof. Fred Starr, of the Chicago University, Ill., stated (Nov. 8, 1896, in the Chicago Times-Herald, which paper I could not obtain) a theory "that there is a tendency, growing out of natural conditions, for the whites who move to the American continent to assume more and more the aquiline features of the Indian." Prof. Fred. Starr's studies (in answer to a letter to him last February) were the results of "studies and measurements made among the Pennsylvanian Germans." The Bertillon system as applied to measurements of criminals does not pertain to my treatise, from which the ears are excluded, since it is an established fact in criminology that attributed qualities often contain some inherited (atavistic?) and apparently indisputable stabilities. By including the ears and immediate surroundings in a treatise on human physiognomies, many grave errors are allowed to creep in with a whole chain of complications and incompatibilities, such as we notice in some magazine articles. The latero-posterior parts include the ear, such a stable element, as stable as the bony framework.

b. The transverse frontal wrinkles of Europeans are generally wanting in the adolescent American female.

This is a strong and generally acknowledged American characteristic, and often applies also to the younger males. As a rule, the wrinkles, when occurring, are more pronounced in those city people engaged in hard work or in factory life; such wrinkles are the most stubborn vestiges, holding on with great tenacity. The casual occurrence of fine, white, transverse frontal lines in young children born in Denmark, Ireland, England, Norway or Sweden, as observed by the writer, are undoubtedly inherited, and probably of luetic (syphilitic) or tuberculous origin, and as such are of diagnostic value in medicine. They are unlike those mentioned by Piderit, Gratiolet, or Darwin, which are acquired through habit as a permanent result of frequently repeated, transient, mimic actions of the *occipito-frontalis* muscle, that covers the upper head.

c. The tone color of the American voice. In the secret laboratory of Nature was evolved a physiological product in the vocal, laryngeal apparatus, which product was, as the writer remembers distinctly since the time of his arrival in America, thirty-five years ago, styled by his young acquaintance "colored voice." Those men were of American birth and Teutonic descent. At social gatherings it casually happened that doubt was felt as to the American birth of a few young men. The doubtful cases were then investigated a little closer and the trouble soon discovered. It would require too much space to narrate all the interesting particulars found. The numerous vestiges left from the Teutonic stock in the first generation (taking up a narrow field of observation) led us to believe that the offspring from Switzerland, Alsace Lorraine, and Baden, contain the most obstinate elements as regards the quick assimilation of American characteristics. Great uniformity in the color of skin, hair and eyes was noticed. French beauty spots, flat-foot, lisping, tinge of yellow in sclerotic, peculiar pitch of voice, "defective whiskers," etc., are some peculiarities that appear even in the first generation. I surmise that this rather un-American tendency, this marked stubbornness, is due in the parent stock to the (former) inability to mix and intermarry with the more northern stock, and also to their geographical position along the French or Gallic frontier. As a matter of course, the tone color of the male American voice appears during adolescence, analogously with that of the European. However, the writer adds, that boys who immigrated early in life, often acquire almost, or quite, the same color of voice as if American born, and here again, though with some exceptions, the more northern the immigrant, the closer the approximation. The Jewish people evidently possess the quickest power of assimilation, the contrast between North and South being, in the writer's observation, even greater in that respect. The American female voice seems louder and higher than that of her European sister, but here my observations are very limited. The female voice of the European Celtic and British is well known as often guttural, which character is as a rule intensified when American born, and stronger, harsher in country than in the city people.

The rounding off of the American voice, and words, is also exemplified in that of the American negro, as Walt Whitman has pointed out, and we may add this is done with a more melodious effect, than in case of the normal voice of the white people in contrast with the European. The negro dialect is but a parallel, and cannot be misconstrued. Melanism (from *melas*, dark or black) as applied here in connection with sub-racial European pigmentation, appears to have some relation to musical rhythm. We remember small subdivisions in Europe, such as Hungarian, French, Turkish, Bohemian, Italian, Spanish music produced by peculiarly pigmented people, each of them endowed with a different musical air. The Teutonic, the so-called Anglo-Saxons, and the Americans are perhaps those that produce the least melancholic music. Congressman Broussard, of Louisiana, never spoke any English until he came to Georgetown University at the age of 15, and even now probably uses his mother tongue (French) with the greatest fluency. "It is a curious thing," said Mr. Broussard, "how the French language has remained the dominant tongue in my home country. Brought there by Acadians of Nova Scotia in the eighteenth century, it prevails to-day, and I believe it always will. Curiously enough you will find plenty of men in my district with such unmistakable English names as Jones, and Hayes, who cannot write or speak a word of English. Still funnier is the talk of the black people. Their negro-French would be unintelligible in Paris, and yet it is the softest, sweetest, most musical speech I ever heard from human lips. It knows no grammar, but it is the very essence of euphony and melody."—Washington Post. The voice of the American female, when past adolescence, gradually becomes nasal, with a sort of "twang." W. Whitman calls it offensive. My observations in this respect are limited, as I have never noticed the "twang" in the first generation of Germans; but I found that it can be forcibly imitated by German females who immigrated in infancy and who lived in society with so-called Yankees; therefore the writer classifies the "twang" as gregarious instinct or imitation from surroundings—simply a bad habit, like the peculiar South German "r." Among the latter it shows emotionality, and among the former a lack of this.

d. The more beautifully animated and glistening sclerotic of the eyes of the American female.

The sclerotic, or the white of the eye, has a faint violet tinge; the glistening is characteristic during the adolescent period. The violet tinge slightly changes in later years in the brunette type into a more yellowish hue. The luster of the eyes is also somewhat diminished at that period in both types, but in order to verify this, comparisons on a large scale are required. The glistening eyes of the American female are most conspicuous when viewed sideways. Occasionally we notice in strongly pigmented Jewish, Italian, and Spanish women a peculiar sharp luster in the eyes, but there is no semblance to the one of the American female. The concomitant motions of the ocular apparatus and surroundings constitute another difference. As the apes and other mammals do not possess a sclerotic, or white, in the eye, but the human eye only has this anatomical trait, and as the esthetological view of J. W. Powell and others is clearly the correct one, the superiority of the female American eye seems to be established. ("Esthetological" means a combination of esthetic and pleasure or attraction.)

e. The less violent, more considerate emotions in either sex.

In the normal state of health this holds good. Blushing, as it exists in Europe, is much less observed in this country. Miss Helen H. Thompson has proved by numerous psychological experiments that men are more emotional than women.

f. The quicker perception of thought, more to the point. The thought is not hampered, and is free from the traditions and prejudices of Europe.

g. The American gestures. These are a great improvement, not only on those few of the Anglo-Saxons and Celts, to say nothing of the sign language of Italians, and the myriads of the rest of Europe. The gestures are, in the writer's opinion, reduced in number for the reason that the more elaborately produced surface of the features in the American, together with other mutations, so functionate as to obviate the need of doing away with some of Europe's superfluous gestures. Since the Americans are not a sub-race of the Anglo-Saxons alone, the supposition of reduction of gestures from that factor solely is out of question.

h. The American round handwriting. The pleasing round handwriting of the male American, so seldom used among Europeans, is simply the result of the teachings in the public schools. There is no doubt as to the superiority of the round handwriting over the pointed, stilt-legged writing of the European script. In a certain way it can be compared with that of stylographic pen-writing, but this comparison is of course far from telling all. Bismarck stubbornly clung to this script, and if it had not been for him, the Germans would, like their Dutch and Scandinavian kin, together with the metric system, have adopted the Latin letters in their print and writing, thus gradually extricating themselves from the medieval ways introduced by obstinate monks. Prof. O. Weise's brochure, "Unsere Muttersprache, ihr Werden und ihr Wesen," says, on page 46: "Another thing is that we, unlike other nations, take upon us the burden of two alphabets, viz., aside from the stilt-legged, odd letters, so peculiar to the German form and manner, which in the course of time have been derived from the round Latin letters, we also use the letters that were prevalent during the middle age. If pedantry had never existed before, the Germans would have undoubtedly discovered it."

* NOTE.—The term "race," or "nation," concerning the American people is but a phrase used at random by the writer. Zoologically considered, the Americans are a sub-species or a racial variety, a psycho-physiological unit or entity, peculiar to the present population of the United States of America.

THE SCHEBLER AUTOMATIC CARBURETER.

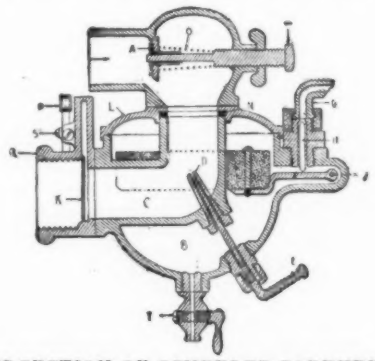
THE accompanying illustrations show an improved automatic carbureter of simple construction, and which has been found to give complete satisfaction to all automobilists who have adopted it. After a thorough test by the manufacturers, it is being placed

SCHEBLER AUTOMATIC CARBURETER.

on several of the leading American machines this year as part of the regular equipment.

As can be seen from the diagram, the carbureter consists of a gasoline chamber, *B*, through which passes an elbow pipe, *C*. A lid, *L*, fits tightly on the chamber, *B*, a tight joint between this and the elbow being made by means of a gasket, *N*. A dome-shaped pipe containing the auxiliary air valve, *A*, is bolted to the lid. This valve is so arranged that when it is completely closed, there is a small air passage past it, as shown. This makes increased suction at the inclined spraying nozzle, *D*, and causes the proper quantity of gasoline to be drawn into the motor in starting, when it is being turned over by hand. As the motor speeds up, the suction tends to increase. This causes the air valve to open, thus making a freer passage for the air and keeping the suction past the jet always approximately the same, with the result that the mixture is kept about the same at all speeds—a thing greatly to be desired.

The gasoline is maintained at the proper level in the



CROSS-SECTION OF SCHEBLER CARBURETER.

chamber by means of a horseshoe-shaped cork float, thoroughly shellaced and placed around the elbow. This float is attached to a long lever, which raises a needle valve, *H*, and shuts off the gasoline entering through *O* when this has raised the float to the proper level. The great leverage obtained to close the needle valve makes flooding of the carbureter from the valve not closing properly almost an impossibility. The needle valve, *E*, of the spraying nozzle is a substantial one with a large, straight handle. It can be readily set and locked in place. It is generally set about

one-half turn open, and the tension on the air valve spring is then adjusted to suit by turning the thumbscrew shown. The carbureter has a shutter throttle valve, *K*, pivoted at *S* and adapted to be operated by a connection at *P*. A drip cock at *T* makes it possible to drain off any water or dirt that settles in the chamber. In the cut of the carbureter, a primer for depressing the float and flooding the carbureter is shown on top at the left and directly below the thumbscrew.

ENGINEERING NOTES.

The proposed railway from Damascus to Mecca has been completed as far as Maan, and this portion is about to go into operation. On this section there are 24 stations, 65 bridges, a viaduct 60 meters in length and 20 meters in height, and a tunnel 140 meters in length. A branch connects Derat with the port of Haifa on the Mediterranean and another with the French Hauran line. According to the Zeitschrift des Vereins Deutscher Ingenieur, the cost has been only $7,200 per kilometer, on account of the employment of 5,000 Turkish soldiers in the work. The country so far opened produces cereals, phosphates, petroleum, asphalt, and other bituminous products.

Railways of the Extreme Orient.—The Zeitschrift des Oesterreichischen Ingenieur-Vereins reviews the Japanese, Corean, and Russian railways and the part they have played in the war of the past year. Japan has, besides the state roads, eight principal lines, those of Nippon, Kimshin, Sango, Hokaido-Tango, Kansai, Hokugetsu, Sobu, and Hankaku. They cover 8,490 kilometers, 1,900 more than in the preceding year. In Corea there are the Chemulpo-Seoul, the Fusan-Seoul, and the Niju-Seoul, the two latter under construction by the Japanese. In this part of Asia there are three gages, 1 meter, 1.44 meters, and 1.59 meters, the Russian gage necessitating a work of unification hereafter. Details of the Transsiberian and of the Transmanchurian railways have been already published.

The fragility of steel is often its most important property from an engineering point of view, yet the tension test gives very little information regarding it. Hence it is interesting to learn that the Fremont machine for determining this property is now made in the United States by the Olsens, who are also prepared to make commercial tests with such a machine in their own laboratory. The Engineering Record is strongly of the opinion that samples of structural steel, boiler plates and the like which fail in service should be tested on such a machine as well as in a tension machine. If this is done it is not at all unlikely that the importance of the impact test will be speedily demonstrated. It does not require expensive apparatus, the samples are easily prepared, and the tests are quickly made. The attention of boilermakers in particular should be given to the Fremont apparatus. —Engineering Record.

Filtering Slabs of Armored Concrete.—The city of Paris has introduced an improvement in the construction of the filtering basins. Hitherto the layer of sand was supported by a series of beds of gravel increasing in size. This arrangement for retaining the sand and forming a drain for the filtered water was costly and attended with various inconveniences. M. Dejust, one of the city engineers, charged with the construction and maintenance of the works, has the idea of replacing these beds of pebbles with slabs of partly reinforced concrete, sufficiently porous to allow the water to pass and sufficiently resistant to support the layer of sand. A test has been made at one of the basins of Ivry, with satisfactory results. The slab consists of a concrete of fine gravel and cement of good quality, setting slowly, in the proportion of ten parts of gravel to one of cement. Irons are set in the mass for the purpose of producing the resistance required. Whether this arrangement will improve the purification of the water directly or not, it will indirectly, since it allows of increasing at the same expense the thickness of the layer of sand 37 centimeters, the former support being 50 centimeters thick and the new only 13. The purification of the water corresponding to the thickness of the layer of sand, this will be a great gain.

In a recent issue of the Proceedings of the American Society of Civil Engineers, Prof. Johnson presents some additional data which surpass the results previously given by him. In the later experiments forty students with an average weight of 158.8 pounds, assembled in the test chamber, resulted in the load of 176.4 pounds per square foot. Then forty men weighing 163.2 pounds each were put in the pen, with the resultant load of 181.3 pounds per square foot. We are told that the latter lot were "all undergraduate students of engineering," but it is quite probable that architectural students would have acquitted themselves equally well. From figures obtained by Dr. Sargent, of Harvard gymnasium, with the aid of a planimeter, it appears that the cross-section of a man standing 6 feet 3 inches high may easily reach 117 square inches, with a corresponding weight of 177 pounds. This gives 218 pounds per square foot, which can be regarded as the maximum unit load of a crowd. In view of the photographs and data now before us, it is impossible to avoid the conviction that live loads of 170 pounds per square foot are by no means unlikely, and that loads of from 130 pounds to 140 pounds must often occur in crowded buildings. Further, as Prof. Johnson points out, the careful designer will remember that 180 pounds per square foot is well within the range of probabilities.

SCIENCE NOTES.

The maker of wine has not been quick to take advantage of the information furnished by botanical research, and in many cases the results of his labors are lost, or at most, the product is often far from what it might have been had the proper plant furnishing the proper enzyme been specifically added, instead of its being left to chance. While it is true that there may be difficulties attending the sterilization of the grape must, which, of course, is laden with wild yeasts and molds, to say nothing of the bacteria, it seems more than probable that by proper attention to the acidity of the must and by adding the pure yeast in considerable quantity so as to overcome the objectionable forms, most beneficial results may be obtained. Certainly, the only way in which the making of wine is to be placed upon the same precise and satisfactory basis as that of malt liquors, is by investigations concerning the purely scientific processes involved and not by a continuation of the old hit-or-miss, inaccurate methods developed centuries ago, before there existed any botanical research.

The debt owed by the tiller of the soil to the vast number of purely botanical investigations of so much money value to the farmer, is but seldom recognized or acknowledged. To admit one's self a scientific farmer is to at once invite a deluge of almanac and comic weekly jokes that have been accumulating against this class since Adam began to work for his living. And yet, barring conditions beyond the control of man, the only way in which the most profit can ever be obtained from a farm is by adhering rigidly to the information based on pure science, much of which has been discovered in the botanical laboratory. It is quite true that certain wild speculations, masquerading as scientific research, have resulted in unjustly causing many practical men to look upon botanical investigation as being the last thing to prove beneficial to those who grow plants for profit. But the farmer is beginning to distinguish between the real and the false, and it will not be long until it is recognized that the only man who fails to make a success out of his land is the unscientific one, who either can not or will not take advantage of the practical facts put at his command by the investigator in the laboratory, who may not know the difference between a double shovel and a disk harrow.

The investigation of the bread yeasts offers a fertile field for some botanist desiring to be of service to his fellow-man by improving one of the most necessary and important manufacturing processes carried on in domestic life. An examination of many of the yeast cakes upon the market will show that they usually are as rich in bacteria as in yeast cells, no particular care having been taken to maintain the purity of the yeast. While we have had some investigations pointing out the bad effect of certain of these bacteria upon the bread sponge, it is more than likely that other bacteria may be of great importance in converting the starch to sugar; at any rate, definite scientific knowledge is necessary before we can hope to get the best practical result. The possibility of improving the bread yeast itself is also a piece of work which has not yet been undertaken. When it is remembered that the source of most bread yeast is a beer yeast, and the function of the two is not by any means the same, it would appear that some careful cultural work would be calculated to greatly improve the ease and certainty with which good bread might be made. Another possible point of improvement lies in the fact that the bread yeasts on the market are generally selected because of their rapidity of multiplication. Since it is now known that this function generally varies inversely as the gas-forming power, it would seem more than likely that by no means the most efficient type of yeast was now being used for bread-making purposes.

In the third and last of his course of lectures on the "Electrical Properties of Radioactive Substances," delivered at the Royal Institution recently, Prof. J. J. Thomson began by discussing the energy given off by radium, and pointed out that most of it was contained in the α particles. Indeed, so great was the energy these contained that it could easily be detected by electrical means even when they were being given off at the rate of only one a minute, the test being thus infinitely more delicate than anything that could be accomplished by chemical methods. Radium gave out sufficient energy to raise its own mass 1 deg. C. in temperature every 36 sec. Turning to the δ rays, he showed that they were certainly given off by an alloy of sodium and potassium under the influence of light, and he thought also when there was no light. Rubidium yielded them still more freely, and probably they were also emitted by substances not classed as radioactive. Radioactivity meant that some change was going on in the radioactive body. In radium, for example, the particles as a whole were behaving in a commonplace manner, but here and there some of them were undergoing the change that was the source of radioactivity and were suffering a breaking-down process, which had already been traced through several stages. It was only at the end of its career, after persisting unchanged for centuries, that the radium atom showed any peculiar properties, and this was a warning against assuming too hastily that because a phenomenon, such as the rising of the sun, had happened an indefinite number of times in the past, it was therefore going to continue indefinitely in the future. A spinning-top might be made big enough to maintain its stability for days, but there came a time when a critical value was reached below which equilibrium could not persist. The case of radium was analogous. Finally, Prof. Thomson asked whether radioactivity was a widely diffused property of matter, or was confined to a small number of substances. The question was difficult, because radium was a very prevalent element which he had found in Cambridge tap-water, in the soil of the ground, in wheat-flour, and many other things, and its presence would confer radioactivity on substances not intrinsically radioactive. Still, investigations which had been carried on in the Cavendish Laboratory at Cambridge he thought afforded conclusive evidence that many ordinary substances were intrinsically radioactive to a very small extent.

ELECTRICAL NOTES.

A new electric process of producing an extremely white flour has recently been adopted in Paris. Specimens of the flour before and after the treatment have been examined by M. Balland, who finds that although the whiteness is undoubtedly increased, yet the flavor and odor are not so good as before. This is shown by the analyses to be due to a partial decomposition of the wheat oil, to which flour owes its aroma, and the flour increases greatly in acidity through this decomposition. In fact the process is essentially an artificial ageing accompanied by the usual whitening that occurs in old flour.

It has been decided by the Prussian Minister of Public Works that the employment of electricity as a motive power for long-distance trains has not yet become practicable. This decision is influenced principally by the question of expense, the fact that enormous improvements are being made in the construction of steam locomotives, and the very serious loss which the State would sustain, owing to the circumstance that an immense quantity of valuable railway material could not be adapted for use under such altered conditions. The advocates of electric traction, however, hope that the government will still regard favorably the project for uniting Berlin and Hamburg with a high-speed electric railway, which has been lodged in the railway department. The project is based on the manifest inadequacy of the present railroads connecting the two cities to deal with the traffic, so there would be no question of competition.

The metal used in the ideal metallic filament long sought for and now claimed to have been discovered by Dr. Von Bolton in the interests of Siemens & Halske, is tantalum, but tantalum absolutely pure. As ductile as steel, it can be drawn out in fine wires; its resistance is fifty per cent greater than that of steel. It bears without softening the necessary temperature for attaining full incandescence. Like platinum, it resists the action of the most energetic acids, and has the advantage over carbon that its electric resistance is quintupled in passing from the ordinary temperature to that requisite for incandescence. It is obtained by the reduction of potassium fluo-tantalate by means of potassium or sodium; the fusion is repeated in vacuum to eliminate all traces of oxygen.

A communication to the Berlin Association of Electricians by W. Siemens, from which these facts are drawn, states that the house of Siemens & Halske has arranged for the daily production of a thousand lamps.

The Electrotechnische Zeitschrift publishes a detailed report by Herr Woege of his researches on the electrostatic rigidity of insulators in different states. He had shown previously that the maximum tension E of the alternating current passing through a distance d in the air may be expressed by the relation

$$E = Ad + B$$

A and B being constants. He gives a table with curves up to 150,000 volts of the explosive distances in oxygen, lighting gas, carbonic acid, and hydrogen, and shows by comparison with previous experiments that if the maximum tension is considered for the alternating current, the explosive distances are practically the same for the continuous current. He sets forth the tests made with various bodies (ether, petroleum, paraffine, oil, linseed oil, etc.) and shows, starting with a certain explosive distance, that its relation with the tension is also linear. His investigations have also extended to solid bodies, whose resistance to the spark depends on the medium in which they are. Experiments on glass lead him to conclude that the relation mentioned applies equally to solids. In a word, this relation is general, at least for discharges between points. It is verified substantially for gases, liquids, and solids.

The Builder contains this interesting extract from its issue for March 17, 1855: "Telegraphic Progress.—Telegraphing Without Wires!—Among the most startling wonders of this wonder-working age, is the announcement that M. Bonelli, of Turin, has invented a new electric or magnetic telegraph, by which trains in motion on a railway are enabled to communicate with each other at all rates of velocity, and, at the same time, with the telegraphic stations on the line, while the latter are simultaneously able to communicate with the trains; and it is added that M. Bonelli is in possession of a system of telegraphic communication by which wires are entirely dispensed with. The idea, however, is not new; we have repeatedly alluded to its possibility; but like multitudes of such ideas the suggestion drops into oblivion and reappears after a while as a fresh novelty. Who was its real originator we do not know, but the nearest approximation to its practical realization we remember anything of was the mode by which a Dundee gentleman transmitted messages across rivers and straits without any intervening or subaqueous wire. Still wire was necessary, and a good long coil, too, at either extremity of the space telegraphed through."

TRADE NOTES AND RECIPES.

For a Paper Gloss.—Grate 12 parts of white Marseilles soap and melt it with 30 parts of blanched carnauba wax, to this add 20 parts of pulverized chalk, and stir constantly until it stiffens.—Nouvelles Scientifiques.

Dentifrice.—Powdered camphor, 6 parts; myrrh, 15 parts; powdered Peruvian bark, 6 parts; distilled water, 12 parts; alcohol of 80 deg., 50 parts. Macerate the powders in the alcohol for a week and then filter.—Parfumerie et Savonnerie.

Brilliantines.—1. Alcohol, 100 grammes; castor oil, 25 grammes; Peruvian bark extract, 5 grammes; essential oil for perfuming, 1 gramme.

2. Alcohol, 100 grammes; castor oil, 20 grammes; glycerine, 100 grammes; essential oil for perfuming, 2 grammes.—Corps Gras Industriels.

For the Preservation of Carpets.—Lay sheets of brown paper under the carpet. This gives a soft feeling to the foot, and by diminishing the wear adds longer life to the carpet, at the same time it tends to keep away the air and renders the apartments warm.—La Tapisserie.

A Cement of Soluble Glass.—It has been suggested to employ under certain conditions soluble glass as a binder with sand to form artificial stone. Soluble glass, that is to say a silicate of soda or of potassium, is brought in contact with calcium chloride, which forms a silicate of calcium, assuring the compactness of sandy materials.—Centralhalle.

Polishing of Aluminium.—Aluminium is susceptible of taking a beautiful polish. This unfortunately is not white, like that of silver or nickel, but slightly bluish like tin. The shade can be improved. First, the grease is to be removed from the object with pumice stone. Then, for polishing, use is made of an emery paste mingled with tallow, forming cakes which are rubbed on the polishing brushes. Finally, red polishing stuff is employed with oil of turpentine.—Chemische Revue.

Harmless Colorants for Foods.—To obtain, for example, a handsome yellow color for cheese, such as is demanded for certain sorts, boil together 100 parts of annatto and 75 parts of potassium carbonate in from 1½ to 2 liters of pure water; let it cool, stand it aside for a time, and filter, adding finally from 12 to 15 grammes of boracic acid as a preservative. For coloring butter, there is in the trade a mixture of bicarbonate of soda with 12 per cent to 15 per cent of sodium chloride, to which is added from 1½ per cent to 2 per cent of powdered turmeric.—Chemiker Zeitung.

Glue for Paper and Metal.—A small quantity of carbonate of potash or of soda is frequently added to flour paste, but this preparation spoils rapidly. A glue which will keep well and adhere tightly is obtained by diluting 1,000 grammes of potato starch in 1,200 grammes of water and adding 50 grammes of pure nitric acid. The mixture is kept in a hot place for forty-eight hours, taking care to stir frequently. It is afterward boiled to a thick and transparent consistency, diluted with water if there is occasion, and then there are added in the form of a screened powder, 2 parts of sal ammoniac and 1 part of sulphur flowers.—Science Pratique.

Alloys for Casting Objects in Brass.—If it be desired to cast brass objects in sand, it is recommended not to make use of alloys containing more than 30 per cent of zinc. This is an alloy which furnishes a good color, casts neatly, and flows well; one may add to it either tin or lead without seriously modifying its properties. A good formula is one giving 3.20 kilogrammes of copper, 1.36 kilogrammes of zinc, 120 grammes of tin, and 90 grammes of lead. The product thus obtained is capable of great resistance, and it may be rendered still harder by slightly increasing the amount of tin.—Metallarbeiter.

Process for Cold Nickeling.—Nickeling may be performed on all metals, cold, by means of nickelene by the Mitressey process, recently introduced in France, without employing electrical apparatus, and any desired thickness deposited. It is said to be more solid than nickel.

First Bath.—Clean the objects and take 5 kilogrammes of American potash per 25 liters of water. If the pieces are quite rusted, take 2 liters of chlorhydric acid per 1 liter of water. The bath is employed cold.

Second Bath.—Put 250 grammes of sulphate of copper in 25 liters of water. After dissolution add a few drops of sulphuric acid, drop by drop, stirring the liquid with a wooden stick until it becomes as clear as spring water.

Take out the pieces thus cleaned and place them in what is called the copper bath, attaching to them leaves of zinc; they will assume a red tint. Then pass them into the nickeling bath, which is thus composed:

Cream of tartar	20 grammes
Sal ammoniac in powder	10 grammes
Kitchen salt	5 grammes
Oxychlorhydrate of tin	20 grammes
Sulphate of nickel, single	30 grammes
Sulphate of nickel, double	50 grammes

Remove the pieces from the bath in a few minutes and rub them with fine sand on a moist rag. Brilliancy will thus be obtained. To improve the appearance, apply a brass wire brush. The nickeling is said to be more solid and beautiful than that obtained by the electrical method.

Brilliancy may be also imparted by means of a piece of buff glued on a wooden wheel and smeared with English red stuff. This will give a glazed appearance.—La France Horlogère.

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